THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. V.

No. VII.—JULY, 1898.

ORIGINAL ARTICLES.

I.—Preliminary Note on a New Specimen of *Squatina* from the Lithographic Stone of Nusplingen, Würtemberg.

By Arthur Smith Woodward, F.L.S., F.G.S.

PLATE X.

SEVERAL specimens of extinct species of the angel-fish or monk-fish (*Squatina*) are already known from the Lithographic Stone (Lower Kimmeridgian) of Bavaria, Würtemberg, and France; and some of these are in an admirable state of preservation. Two forms are clearly distinguishable—the one a small fish not more than 0·15 m. in length, with a dense armour of rounded dermal tubercles on the anterior border of the head and each of the paired fins, and upon the lateral aspect of the tail;[1] the other a comparatively large fish, attaining a length of at least a metre, without any similar development of the dermal tubercles, either in the regions mentioned or on any other part of the body.

An imperfect example of the latter fish from Eichstädt, Bavaria, was originally described by Münster[2] under the name of *Thaumas alifer*, and subsequently referred by Giebel[3] to the existing genus *Squatina*. Some years afterwards a finer specimen, either of the same or a closely allied species, from Nusplingen, Würtemberg, was described in detail by Fraas[4] under the name of *Squatina acanthoderma*. In 1859 the specific identity of this fish with the Eichstädt fossil was first maintained by Von Meyer;[5] and still more recently the same opinion was expressed by Von Zittel,[6] who briefly described and figured a nearly complete example from Eichstädt more than a metre in length. Quite lately an equally fine specimen has been obtained by Mr. B. Stürtz from the classical quarry at Nusplingen; and it is thus possible now to compare complete examples of the fish from the Bavarian and Würtemberg localities.

[1] *Squatina speciosa*, H. von Meyer: Palæontographica, vol. vii (1859), p. 4, pl. i, fig. 2.
[2] Münster, "Beitr. Petrefakt.," pt. v (1842), p. 62, pl. vii, fig. 1.
[3] Giebel, "Fauna der Vorwelt—Fische" (1847), p. 298.
[4] O. Fraas, Zeitschr. deutsch. geol. Ges., vol. vi (1854), p. 782, pls. xxvii–xxix.
[5] H. von Meyer, Palæontogr., vol. vii (1859), p. 3.
[6] K. A. von Zittel, "Handbuch der Palaeontologie," vol. iii (1887), p. 92, fig. 105.

The new specimen from Nusplingen has been acquired by the British Museum, and is shown of about one-eighth the natural size in the accompanying photograph (Plate X). It measures 1·12 m. in total length, and is exposed from the dorsal aspect, exhibiting the complete outline of the fish, with all the fins. The tail is observed to occupy about one-half the total length of the fish; and the maximum width across the pectoral fins is somewhat less than half this length. The cranium and cartilages of the jaws, so far as they can be distinguished, are essentially identical with those of the recent *Squatina*; but the dentition is unfortunately not displayed.

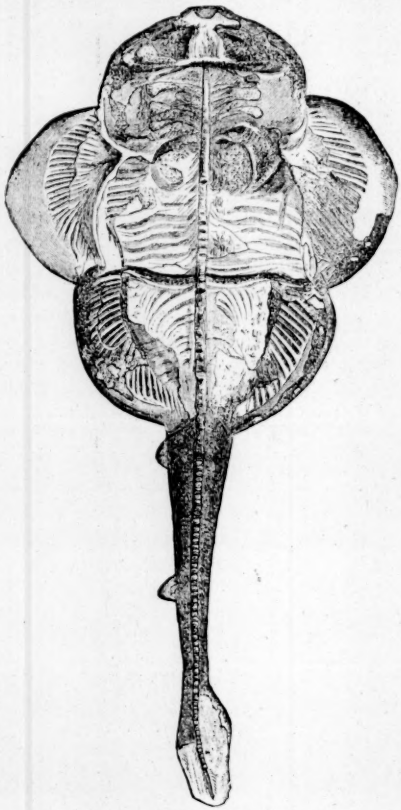


Fig. 1.—*Squatina alifera* (Münster).
Lithographic Stone (Lower Kimmeridgian): Eichstädt, Bavaria.
(From Von Zittel's "Handbuch.") One-tenth nat. size.

The vertebral column is complete, comprising about 150 well-calcified centra; and there are traces of the slender abdominal ribs in the region of the pelvis, while some of the laminar neural spines are seen both at the base of the tail and near its extremity within

the caudal fin. The characteristic pectoral arch and three basal cartilages are well preserved, especially on the right side; but the radial cartilages of the great pectoral fin are scattered and only imperfectly shown—indeed, partly destroyed. The imperfect pelvic cartilage lies beneath the thirtieth and thirty-first vertebral centra, where there is a slight displacement of the column; and the cartilages of both pelvic fins are somewhat scattered, though the long and slender basipterygium is distinct and in position on the right side. The anterior dorsal fin arises quite at the base of the tail, and is apparently similar in size to the posterior dorsal, which is separated from it by a space not exceeding the length of its base of insertion. The caudal fin is rather large, its extent considerably exceeding one-third the length of the tail. The trunk and fins are completely covered with very fine shagreen, which is apparently not enlarged or modified into spinous tubercles on any region.

On comparing this new fossil with the type-specimen of *Squatina acanthoderma*, of which there is a good plaster cast in the British Museum, it will be observed to agree precisely in the proportions of all the parts preserved. On the other hand, judging from the figure of the Eichstädt fish published by Von Zittel (Fig. 1), there seem to be several important differences between the latter and the new specimen from Nusplingen. For example, the Eichstädt fossil is represented as having a larger and broader head, relatively smaller pectoral fins, and much smaller and more widely separated median fins. These differences may, of course, be partially explained by imperfections in preservation, and differences in the mode of crushing; but it is obvious that the specific identity of *Squatina acanthoderma* from Nusplingen and *Squatina alifera* from Eichstädt is by no means established.

II.—On some Triassic (?) *Estheriæ* from the Red Beds or Cimorron Series of Kansas.

By Professor T. Rupert Jones, F.R.S., F.G.S.

PROFESSOR CHARLES S. PROSSER, Geological Department, Union College, Schenectady, N.Y., having sent me some specimens of *Estheria* found in the Red Beds or Cimorron Series of Kansas, with the request that I would determine the species, my notes on them are here offered to the Geological Magazine, in which other fossil *Estheriæ* from North America have been illustrated and described.

Professor Prosser has treated of "The Cimorron Series or the Red Beds" at pp. 75–95 of "The University Geological Survey of Kansas," vol. ii, 1897; and in the "Kansas University Quarterly," vol. vi, No. 4, October, 1897, p. 151, Professor Prosser, in giving an account of the Red Beds or Cimorron Series, states that Mr. C. N. Gould had lately found a number of invertebrate fossils (presumably the *Estheria* under notice) in a soft red sandstone not more than 100 feet above the base of the Red Beds or Cimorron

Series, eight miles west and three miles south of Hunnewell, Sumner County, Kansas.

Two of the longer and one of the shorter forms are here figured.

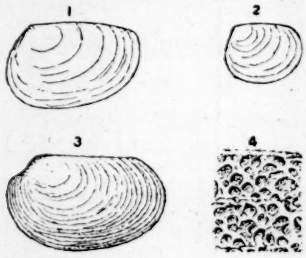


Fig. 1.—Oblique-oblong, deeper in front than behind; umbo forward and rather prominent; dorsal margin nearly straight or very slightly convex; ventral margin elliptically curved, full in the anterior region. Measures 4·5 mm. in length, and 2·5 mm. in height. Magn. 4 diam.

Fig. 2.—Smaller form, subquadrate, rounded behind, subtruncate in front, probably a young condition. It measures 2·5 by 2·0 mm. Magn. 4 diam.

Fig. 3.—The interior of the mould or hollow cast of a larger and more oblong variety. Magn. 4 diam.

Fig. 4.—Irregular and variable siliceous deposit among the sand-grains. Magn. 30 diam.

Among the specimens some have the following different measurements, but all appear to belong to one species: 5 × 3 mm.; 4·5 × 2·5 mm.; 4 × 3 mm.; 4 × 2·5 mm.; 2·5 × 2 mm.

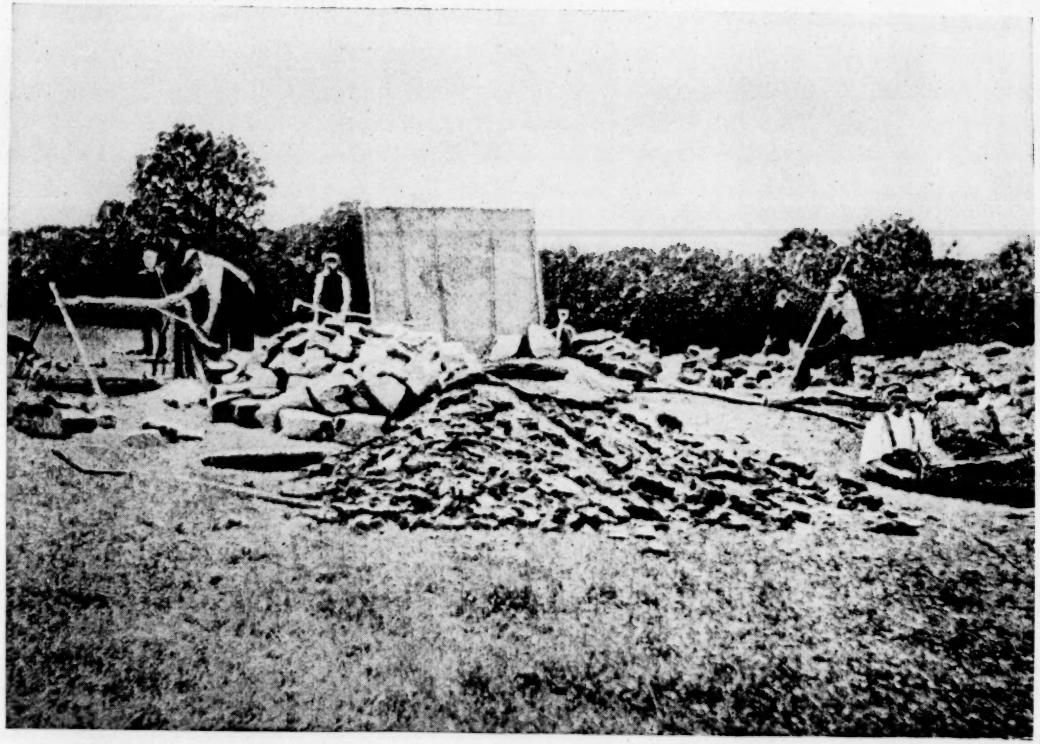
Of the published forms the one that approaches most nearly this *Estheria* from the Red Beds of Kansas is shown by fig. 1, pl. ii, "Monograph Foss. Estheriæ," Pal. Soc., 1862, and described at p. 57, etc. This measures 5·5 by 3·6 mm., and is rather higher in the posterior region than the sketch, Fig. 1, here given.

The smaller form (Fig. 2) has an analogue as to shape in fig. 4 (5·3 by 4·0 mm.), and as to shape and size in fig. 14 (2·5 by 1·8 mm.); also in the somewhat similar young, sexual, or varietal forms of other species.

We may also compare the larger of the first two sketches with Fig. 3, Pl. XI, Geol. Mag., Dec. IV, Vol. IV (1897), described at p. 290 (*Estheria Mawsoni*, from the Cretaceous strata of Brazil); but here the antero-ventral region is too prominent. Its interstitial ornament is of a *bar* pattern, of which we have no indication in the Kansas specimens. It measures 5·3 by 3·6 mm.

The figs. 26 and 27 of pl. iii, "Monogr. Foss. Esth." (about 5·3 mm. in length), approach in shape, and they exhibit good examples of the prominent umbo; but their interstitial ornament is bar-like.

Estheria Lewisii, J., from Bucks Co., Pennsylvania (Geol. Mag., Dec. III, Vol. VII, 1890, p. 385, Pl. XII, Figs. 3*a*, *b*), measures 5 by 3 mm., and is too broadly and fully curved on the ventral margin, and too high in the posterior region, to match the Kansas form.



Modern "Dene Hole" Makers working in the "Purbecks" of Brightling, Sussex.

The picture shows four pits in all stages of the working and completion.

Estheria Hindei, J., from Phœnixville, Pennsylvania (GEOL. MAG., Dec. III, Vol. VIII, 1891, p. 51, Pl. IX, Figs. 5–8), measures 7 by 4·5 mm., and is nearly oblong, that is, higher anteriorly; and although much like the Kansas *Estheria*, its relative size, small umbo, and boldness of the concentric striæ are distinctions; and there is no trace of its bar ornament in the other form.

Imbedded in a coarse sandstone, the Kansas *Estheriæ* are too badly preserved to exhibit their interstitial sculpture. Their concentric lines of growth are recognizable (Fig. 3), but nothing else satisfactorily. There is a delicate, siliceous, irregularly reticulate, white infiltration among the grains of quartz (Fig. 4), which gives in the hollow casts a false appearance of ornament, especially where the concentric lines are present; but it cannot be so regarded at all.

The relative specific value of the North-American *Estheriæ* and portions of their ornament, figured in the "Monogr. Foss. Estheriæ." 1862, has been estimated by me in the GEOL. MAG., 1890, p. 386, and 1891, p. 51.

The conclusion arrived at is, that the *Estheriæ* from the Red Beds (or Cimorron Series) of Kansas and Oklahoma should be registered the same as the Triassic *Estheria minuta* (Alberti). If, however, the interstitial ornament is found well preserved, it may prove the species to be different.

III.—Ancient and Modern "Dene Holes" and their Makers.

By CHARLES DAWSON, F.S.A., F.G.S.

(PLATES XI AND XII.)

THE name "Dene Holes" has been locally given to certain ancient artificial caverns usually found excavated in the Chalk of Essex and Kent. They have deep vertical entrances by shafts, being of varying depth, but the caverns themselves all bear a general similitude in design. They have been chiefly explored in the counties of Essex and Kent, although they undoubtedly exist in many other counties.[1]

In places where the chalk stratum is overlain by some other deposit, the latter has been cut through by a shaft and the chambers have been formed in the solid chalk below, leaving as a rule only sufficient chalk between the cavity and the superincumbent strata to ensure the stability of the roof.

No spoil heaps of chalk are found near them on the surface, showing that the chalk taken out has been disposed of, and unfortunately nothing has been discovered within the chambers which gives any decisive clue to their age, origin, or use, although from objects discovered many are thus proved to have been in existence for some centuries.

It has been surmised by some that they have been used as habitations, but there is not the slightest internal evidence of this.

[1] The writer and Mr. John Lewis, C.E., F.S.A., descended two very fine ones at Brighton, Sussex. One of these was incomplete with respect to depth. In the floor were excavated two or three steps. The workmen seemed to have been excavating the chalk laterally from these steps and thus lowering the floor.

Others imagine that they were hiding-places or stores for crops, but both these latter suggestions, in absence of direct evidence, are rendered unlikely by the size, depth, and number of the pits, and their close proximity to one another. They differ very much from those much smaller beehive-shaped excavations discovered in Portland and which, with probability, may be considered to represent a type of the true silos or grain-pits of ancient writers.[1] The dene holes are of very considerable size and would have held an enormous amount of grain or fodder, and this notwithstanding that their normal size may have been slightly exaggerated by falls of blocks of chalk from the roof and sides. Judging from the wonderful stability of the shafts in many cases, the formation of these particular pits may have extended over some years, perhaps by intermittent excavation until the chambers got too large to be conveniently worked. With respect to similar classes of these excavations existing elsewhere, the stability of the rock and subsoil does not seem to have admitted of this intermittent working.

To those people who have made a study of these excavations[2] the chief points which present themselves as requiring elucidation are as follows:—

If these pits are merely chalk-pits (which theory is the natural presumption which first occurs to the mind)—

1. Why are they frequently clustered together; and although they are dug so close to one another yet they are never intentionally connected?

2. Why are they all constructed on the same general design and seemingly elaborate ground plan?

3. And why were they dug for chalk when chalk itself occurs on the surface less than a mile away?

It will be the object of this paper to answer the above questions by simple comparison of the so-called "dene holes" with excavations of exactly similar character and design, which have been worked for centuries, and which are still being worked in England.

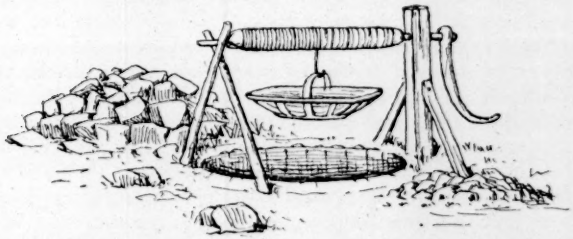
In the centre of East Sussex, in a very old-world neighbourhood, many miles away from any railway station, there is exposed a series of rocks known as the "Purbeck Beds," being the lowest beds exposed in the South-East of England. This strip of ancient strata, as it shows itself, is about $8\frac{1}{2}$ miles long by 1 mile in width. Here and there beds of limestone called "the Greys" and "the Blues" are to be discovered, sometimes cropping out and sometimes occurring within a short distance of the surface. Up to the middle of the present century, and doubtless for centuries past, this stone has been quarried to be burnt for lime, and proved to make a cement of exceptional hydraulic properties.

For many years past the quarrying of the limestone has been given up; but the stone is now being excavated for "road-metal," and thus used for many miles around.

[1] See Mr. T. V. Holmes' paper in the Essex Field Club Transactions, 1887, p. 253.

[2] See Essex Field Club Reports, especially Mr. T. V. Holmes' paper, vol. 1887; also Mr. Miller Christy's paper in the *Reliquary*, April, 1895.

The whole of this area is covered with countless thousands of pits resembling the dene holes of Essex and Kent. They represent, in fact, the result of the usual method of procuring the limestone wherever the stone is quarried from a depth below the surface of the ground. The workmen, who with their forefathers have been accustomed to this industry all their lives, perform the work with wonderful celerity. The stratum of stone having been ascertained to exist near the surface, a well about three to four feet in diameter is commenced in certain blue and brown shales, and usually reaches the limestone within 40 feet (sometimes 50 or 55 feet) from the surface. The cavity above the stone is then belled out on all sides to a diameter varying with the stability of the strata. Sometimes the cavity is 15 or 16 feet in diameter, sometimes considerably more. The stone is then removed, and four small arched lateral chambers are dug at four equidistant points in the side of the bell-shaped cavity so as to extract as much stone as the pitman dare without endangering his life. Three men are employed in and about the hole when in full working order. The stone is hauled up by one of the men on the surface by means of a windlass of very primitive description and a handle of a curved peculiar shape which is characteristic. Sometimes there is a handle each end of the windlass where the work is heavy.



Stone Pit-mouth, showing primitive Windlass and "Trug-Basket."

To the cord is attached a Sussex "trug-basket," in which the smaller fragments of the stone are hauled up; the larger pieces are tied by the cord and hauled separately. The writer made the usual descent into the pit, which is performed by placing the toe on the hook of the cord and holding the rope above, the windlass being carefully unwound by the man at the surface. With a frayed rope not an inch in diameter this may seem dangerous; but few accidents have been known to occur.

While the last pieces of stone are being removed from the pit one of the men commences another shaft about six yards away, so that it may be well forward by the time the other work is completed. Sufficient room is scrupulously left to prevent one chamber encroaching too near to the other, and it is therefore necessary to adopt some regularity in their design. And so the operation is repeated over and over again without any variation of importance.

When asked why they do not run galleries and mine the stone with timbered and propped sides, they say that the way they do it occupies less time, is least expensive, and that they work always in the same general design because they know, by experience, that it is a safe one. Indeed, the whole operation of digging a well and getting out the stone is only a matter of a few days; and they then fill one pit with the débris from another. Their rule of thumb formula as to whether a shaft will pay is: "A foot of dirt to an inch of stone = that pays." The deepest bed of limestone at Worge Farm and Perch Hill Farm, Brightling, is three feet thick; it however runs as thick as four feet in other places. The price of the stone is 4*s.* per yard, and the men have to pay 1*s.* 9*d.* per yard as a royalty to the landlord (1*s.* 6*d.*) and tenant (3*d.*). The workmen clear about 2*s.* 6*d.* to 3*s.* per day. The stone is carted a radius of five miles over hilly country.

The limestone has, however, a bad trick of "thinning out" very rapidly within a short distance, which cannot be discovered from the surface; and partly for this reason, and partly for the economy of the surface space, the pits usually occur in clusters (occasionally one may see these pits at work while another gang are quarrying the stone on the surface where it crops out about 200 yards away). On all sides one may see circular depressions caused by subsidences of the old pits having been insufficiently filled up. Besides these "bell pits" which I have mentioned I should point out that in ages past this system of working was the common one among the ironworkers of Sussex for procuring the iron stone or ore in the "Wadhurst Clay" and the "Fairlight Clays"[1] ("Hastings Wealden Beds"). Large numbers of these pits remain in the woods, but on the pastures and arable fields they are usually less traceable. Waste pits do not occur in connection with these "myne pits," because the lime and marl obtained in digging them was used as a flux for smelting the iron and top as a dressing in cultivation.[2] The chambers are very rarely connected by levels. As these pits occur in association with slag heaps containing Roman remains it is probable that the method of mining is at least as old as the period of the Roman occupation of Britain. The well-known passage from Pliny (the Elder, A.D. 23–79) concerning this class of excavation may refer to these iron mines. In describing the early process of "marling," he says: "Another kind of white chalk is 'Argentaria,'[3] which is brought from a depth of a hundred feet, the pits usually made narrow at the mouth, internally *as in metal mines the vein spreading out* (or widening, 'spatiante vena').[4] They

[1] Near Crowborough Warren New Water Mill.

[2] Beside the writer's own authority on the subject may be quoted Mr. William Topley's memoir on the Weald Geological Survey: see titles "Iron Works" and "Lime."

[3] Argentaria (whitening), so called (as we learn from another passage in Pliny) because of the brightness it imparted to silver when rubbed with it (see book 35, chap. lviii, Pliny's "Natural History").

[4] This passage has been misquoted by modern writers as "the veins running about."

use this chiefly in Britain." (Pliny's Natural History, book 17, chap. viii.)

In some parts of Hertfordshire and Bedfordshire[1] similar pits are still sunk through superincumbent strata for obtaining a chalk dressing, and these pits are of similar character to the "dene holes," and probably many other counties have examples of the working. I do not here propose to say much about the modern Hertfordshire and other recorded chalk pits or wells which belong to this class, but it may be interesting to give a description of these pits of Hertfordshire and Kent, as they were in full working order more than a century ago. They are described by the chief agricultural writers of that time, who wrote perfectly independently and innocently of dene-hole controversies!

I will commence first with Mr. Walker's Report on the Agriculture of Hertfordshire (reprinted by the Board of Trade, 1804; see p. 158), and who appears to have made notes in 1794. He says (see title *Chalk*): "The prevailing practice of sinking pits for the purpose of chalking the surrounding land, enables me to remark in general that the basis of the soil in Hertfordshire will be found to consist of a deep bed of chalk; the superstructure, an irregular indenture of chalk and earth pillars; the earth pillars broadest at top, and narrowing as they descend, the chalk pillars broadest at the bottom, rising conically, and narrowing as they ascend to the surface. The chalk pillars frequently ascend to the surface and form part of the staple, and the whole extent of the apex is visible in ploughed lands. The earth pillars have been found to descend fifty feet and upwards, to the no small mortification of the chalk-pit diggers, who are frequently obliged to abandon a pit which they have sunk in an earth pillar to the depth of twenty feet and upwards, and sink in a fresh pit with better hopes of success.

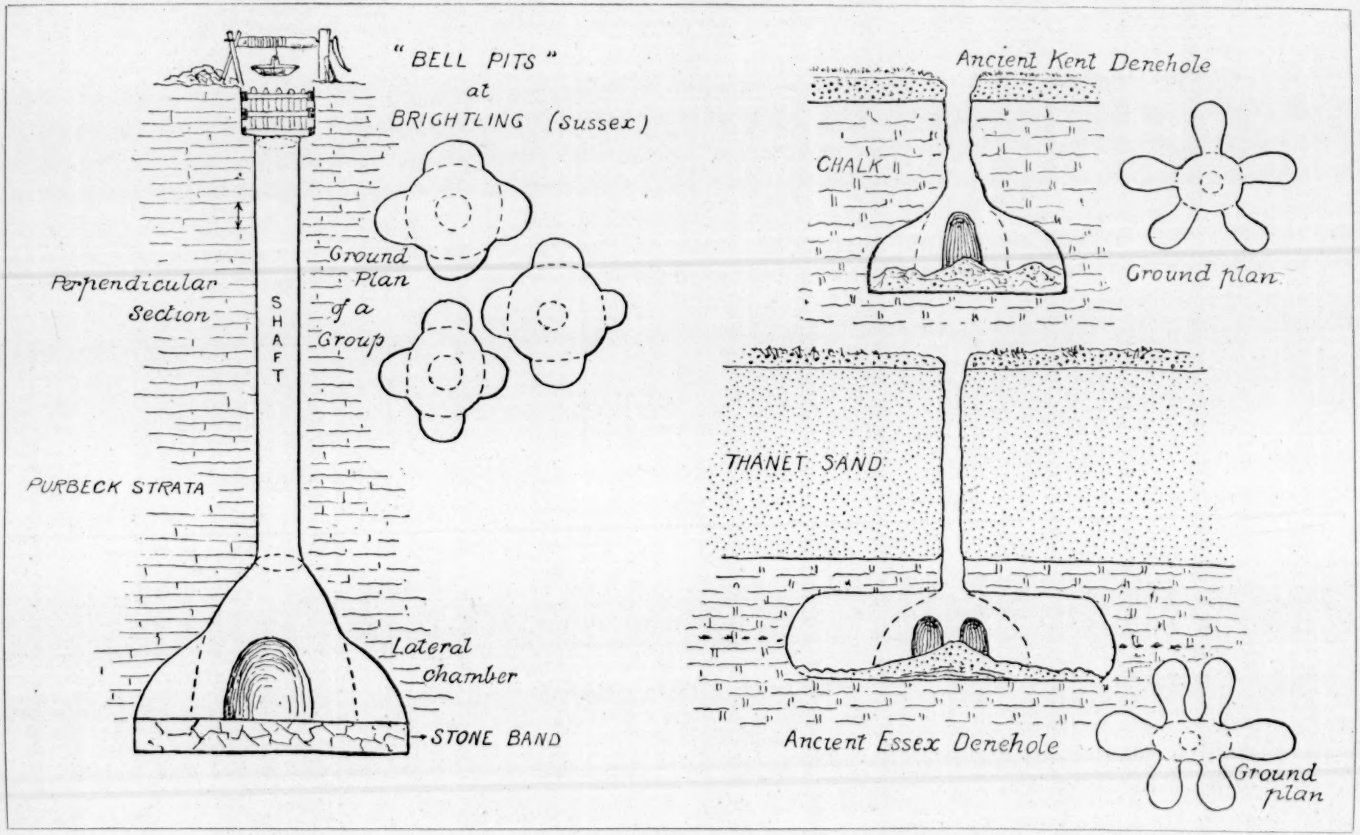
"This general rule, however, admits of many exceptions; the chalk in several parts of the county is covered for many acres together with a great depth of earth, which often renders the question of a chalk basis uncertain, and the downs skirting the county towards Cambridgeshire are for the most part a continued bed of hurlock or bastard chalk covered with a very thin staple."

Our author then proceeds to give a description of the working of these pits.

"The undermentioned method is pursued in chalking land, and the persons employed therein follow it as a trade. A spot is fixed upon nearly centrical to about six acres of land to be chalked. Here a pit, about four feet diameter, is sunk to the chalk, if found within twenty feet from the surface; if not, the sinkers, considering that they are on an earth pillar, fill up the pit, and sink in fresh places till their labour is attended with better success."

He mentions a very curious circumstance which reminds us of the wattled covers to the shafts of the subterranean dwellings

[1] Mackery End Farm, Harpenden; Hyde Farm, near Luton; New Mill End Farm, near Luton; and many others.



Sections and Ground Plans of Ancient and Modern "Dene Holes" in Sussex, Kent, and Essex.

described by Dr. Blackmore and Mr. E. T. Stevens,[1] at Highfield, near Salisbury,[2] namely :—

"The pit from the surface to the chalk is kept from falling in by a kind of basket-work made with hazel, or willow rods and brushwood, cut green, and manufactured with the small boughs and leaves remaining thereon to make the basket-work closer. The earth and chalk are raised from the pit by a 'Jack rowl' on a frame, generally of very simple and rude construction. To one end of the rowl is fixed a cart-wheel which answers the double purpose of a fly and a stop; an inch rope of sufficient length is wound round the rowl, to one end of which is affixed a weight which nearly counterbalances the empty bucket fastened to the other end. This apology for an *axis in peritrochio*, two wheel-barrows, a spade, a shovel, and a pickaxe are all the necessary implements in the trade of a company of chalk-diggers, generally three in number. The pitman digs the chalk and fills the basket, and his companions alternately wind it up and wheel its contents upon the land. When the basket is wound up to the top of the pit, to stop its descent till emptied, the point of a wooden peg of sufficient length and strength is thrust by the perpendicular spoke in the wheel into a hole made in the adjoining upright or standard of the frame to receive it.

"The pit is sunk from twenty to thirty feet deep and then chambered at the bottom, that is, the pitman digs or cuts out the chalk horizontally in three separate directions, the horizontal apertures being of a sufficient height and width to admit of the pitman working in them with ease and safety."

The comparatively small expense of carrying out this mode of chalking is given by the same writer.

"One pit will chalk six acres, laying sixty loads on an acre. If more be laid on, and to the full extent of chalking, viz. 100 loads, then a proportionate less extent of land than six acres is chalked from one pit. Eighteen barrowfuls make a load, and the usual price for chalking is 7*d.* per load, all expenses included, therefore the expense of chalking at sixty loads per acre is £1 15*s.*, and at 100 ditto £2 18*s.* 4*d.*

"As the chalk is considered to be better the deeper it lies, and the top chalk, particularly if it lies within three or four feet of the surface, very indifferent, and only fit for lime or to be laid on the roads, gateways, etc., the chalkers must be directed to lay by the chalk for the first three or four feet in depth, to be applied to the above purpose. If it be not wanted for those uses it is again thrown into the pit. When filled up, Mr. Walker also observes that the flints must be picked out from the chalk before it is carried on to the land, for if the pit-makers are not narrowly watched they will chalk with both."[3]

[1] See Report on the Blackmore Museum, pt. ii, p. 152.

[2] The interior of these dwellings as described are perfectly distinct in form from the so-called "dene holes."

[3] The flints are sometimes found squared, and are used to line the mouth of the well. In the two Brighton ones the upper or bad chalk had been similarly used.

I have taken the opinion of an analyst on the question of chalk quarries from a depth being better than that obtained from near the surface. Mr. S. A. Woodhead, B.Sc., public analyst for Sussex, says:—

"*Calcium carbonate* (chalk) is insoluble in water, but if the water is charged with carbon dioxide the calcium carbonate then becomes soluble, because it is changed into the bicarbonate. From this it is seen that the carbonate may be changed to the bicarbonate, and this bicarbonate is soluble in water.

"If the calcium bicarbonate comes in contact with ordinary lime and water it becomes changed into the carbonate of lime, which, being insoluble in water, is deposited in the same condition as it was taken up, i.e. as calcium carbonate (chalk).

"Below, one gets a more soluble form of chalk, by reason of the precipitation above-mentioned, which, when laid on land containing organic matter, unites with nitric acid found in the soil and forms calcium nitrate (nitrate of lime), which is an actual plant food."

Mr. Walker quotes instances of practical experience in chalking. Mr. W. J. Malden, Principal of the East Sussex Agricultural College, in support of this view says:—"Farmers throughout the Chalk areas invariably lay aside the first few feet in digging a chalk-pit, as common experience has shown that this chalk exercises no beneficial effect, whereas much good is done by that obtained by that lower down."

"Mr. Byde (Ware Park) pays for winding it up in buckets 7*d.* a load of twenty-four bushels, and 8*d.* a foot for the shaft till the chalk is found; the men barrow it on to the land at the distance of twenty poles for 8*d.*, *but then they open a fresh shaft every forty yards.* They have 2*d.* in the shilling for beer, and for filling it into carts and spreading it 4*d.* a load more.

"Forty loads are the common quantities per acre. He finds fifteen loads of chalk per acre *repeated once in ten or twenty years* much better than a large quantity at once."

He sums up the reasons why these pits were used in preference to open workings which, by the distance away, would necessitate the use of horses and carts.

He concludes: "Upon the whole, I must observe that this husbandry, which is general throughout the county, has considerable merit; but the great singularity is the long-established practice of drawing up by shafts and barrowing it on to the land. Those who have been accustomed to the marle carts of Norfolk and Suffolk know what severe work to the teams that business always proves and what a most heavy expense attends it. Horses of great value are often lamed or destroyed, and the purchase of carts and harness, with the wear and tear of both, form very heavy articles. *The Hertfordshire custom is therefore much to be preferred.*

"Two or three pounds per acre could be easily afforded by men who could not set any regular clay carts at work for want of a scale of business proportioned to such teams, etc."

Surprise has been expressed among those who have dug trenches

on the surface near the Essex dene holes that no fragments of chalk have been discovered by them, and this has been looked upon by some as evidence that the excavators of these pits, desiring secrecy, distributed the spoil over a wide area. The following passages from the *Complete Farmer*, 1807, describing this class of chalk-pit, may have a direct bearing on the above subject:—

"In making use of it (the chalk) it should be broken as small as possible. It should be dug near the end of autumn and laid on immediately. At that season the air is generally moist; the moisture will be absorbed by the chalk; this will occasion it to swell and break into pieces, and if frost comes on it will accelerate the business. It should in no case be ploughed in till its parts are properly separated and 'reduced to crumbs,' and then it should be completely harrowed in and mixed with the soil."

Mr. Bannister also says, when land is dressed with chalk, pulverization is the chief aim to secure the full virtue of this manure.

It may seem an extraordinary thing that the practice of chalking from deep wells, like those in Essex, should have ceased entirely and their origin forgotten in that county. At all events, although it seems that these chalk wells were dug in the adjoining counties, we find that in Essex, at the end of the last century, chalk was brought from Maldon, where it was landed in barges loaded from the chalk cliffs of Kent. It cost 10*s.* a load at Maldon, and was then carted several miles into the country to manure the land.

Mr. John Bannister, of Horton Kirby,[1] Kent, writing in 1799 of the practice of chalking, observes that "there are two methods of obtaining chalk; the first is, by uncallowing a piece of ground and making it convenient for a pit, where carts may be drawn into it and there filled. This (open working) is on a presumption that the chalk lies near the surface and that the pit is within a *small* distance of the field on which the manure is to be laid."

The other method is to sink pits in the field where chalk is intended to be laid as manure, *and which, he says, in his opinion, "is far preferable to that of drawing it in carts as before mentioned."* "In this case a number of pits are to be sunk according to the extent of the field. These pits are to be made in the form and circumference of a well with an apparatus at the top and a bucket to draw up the chalk. The people who undertake the business, having been brought up to it from the cradle, perform it with great facility, and without timidity, though attended with much danger. A person is employed at the top to draw up the contents of the pit, shoot the chalk into the cart, and wheel the same on to the land.

"When the labourer has arrived at the chalk, which takes up a longer or less distance of time, according to the depth at which it lies, and has dug some little time therein, in perpendicular form wherein he began the pit, he proceeds to form apertures in different *horizontal* directions; so that where the chalk is good, and the pit stands firm, large tracts of ground are undermined for this purpose."

[1] See his "Notes on Agriculture," chap. xviii, title 'Chalk Manure.'

The Editor of the *Complete Farmer* says: "Obstacles to the work sometimes fall out from the light contexture of the soil, which does not unfrequently give way to the destruction of the chalk drawer. To the farmer it may be of consequence to consider the nature of his land ere he embarks on the scheme of husbandry; as, if from the circumstances above mentioned, he may have reason to think his pit will not stand firm, it would be a matter of prudence to desist from any further thoughts of sinking a perpendicular pit, and change the mode of operation by bringing his chalk from an uncallowed pit or (open working), but where it can be obtained at a moderate expense, and with a tolerable certainty of success, *the preceding method is certainly the most eligible.*"

The writer does not wish to occupy more space by "hammering a driven nail." It must surely be apparent to all those of logical mind who have read and explored both sides of the question that no mystery exists with respect to the "dene holes" in Essex. The whole class of these excavations have their origin and inception of design in the very ancient custom of "bell pit" mining. It might be argued, not unfairly, that the same system of working, identical in general design, may have been made use of for other purposes than for chalk quarries merely; that is, assuming that further evidence exists of their having been so used, which, however, remains to be discovered with respect to the Essex "dene holes."

The writer thinks we may safely say that where such collateral evidence does *not* exist, and pits of this description are discovered from which the chalk has been removed and carried away, that the balance of probability in favour of their having been merely chalk-pits is overwhelming.

DESCRIPTION OF PLATE XI.

Modern Dene Holes and their makers at work in the "Purbecks" of Brightling, Sussex. Picture shows four pits in all stages of working and completion.

IV.—On a New Species of Brachyurous Crustacean from the Chert Beds (Upper Greensand), Baycliffe, near Maiden Bradley, Wilts.

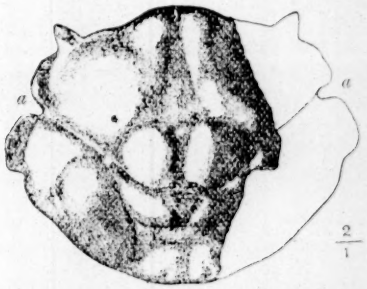
By Henry Woodward, LL.D., F.R.S., F.G.S., etc.

HAVING, in March last, received from Mr. Jukes-Browne, F.G.S., of the Geological Survey, a small carapace of a crab obtained by Mr. J. Scanes, of The School House, Maiden Bradley, from a quarry in the Chert Beds of Baycliffe, near Maiden Bradley, Wilts, I endeavoured to identify it with some species of Cretaceous *Necrocarcinus* already described, but without success. I am therefore reluctantly compelled to refer it to a new species. The specimen is rather imperfect, which renders the task of determining its characters the more unsatisfactory.

The carapace appears to have been nearly equilateral (31 mm. long and 30 mm. broad); the right side is, however, imperfect, and the edge of the posterior border is also wanting. The surface is tumid,

and the centre is divided by a mesial furrow, and transversely by a well-marked cross-furrow ending in a notch upon the lateral border (*a*, *a*). The metagastric lobe is marked by two triangular-shaped swellings on either side of the mesial furrow, with their convex borders directed outwards and their points downwards; at the point of each swelling is a round pore, one being placed on either side of the mesial line: a transverse furrow divides the metagastric swelling from two others, marking the urogastric prominence. These have an indented, V-shaped furrow dividing them in the centre. Behind the gastric region is a lesser single median prominence marking the cardiac region, having two small subcentral puncta on it. On either side, occupying about one-third of the breadth of the lateral border of the carapace, is placed the branchial region. This is marked by a reniform swelling, and is divided from the hepatic region on the latero-anterior margin by a deep rounded notch (*a*, *a*), and by the great median transverse furrow which here crosses the carapace from side to side. The hepatic region is smooth and not elevated; the margin is marked by a single spine on the latero-anterior border, indicating the outer angle of the orbit. The rostrum is blunt and has a broad furrow down the centre, dividing the frontal region into two raised prominences.

The general surface of the carapace is smooth and devoid of tubercles and rugosities, and it is not quite certain in its present state of mineralization whether the outer layer may not have been removed. In any case, the divisions of the carapace are so distinct as to render it capable of determination, and in its present condition this form of *Necrocarcinus* may conveniently bear the trivial name of *N. glaber*.



Necrocarcinus glaber, sp. nov. Twice nat. size.

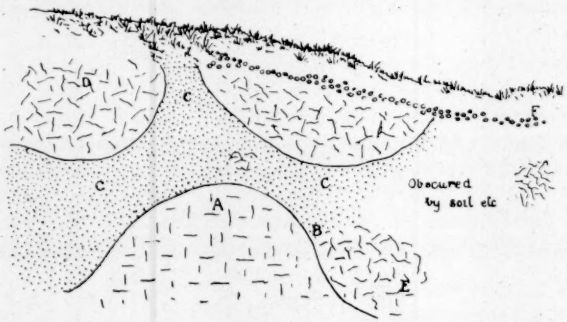
From the Greensand Chert Beds, Baycliffe, near Maiden Bradley, Wilts.

Since the above was written Mr. Scanes has sent up another broken specimen, identical with the above, and in the same condition, so that we may justly conclude that they show the actual surface of the carapace. Mr. Scanes has kindly presented the specimen here figured to the British Museum (Natural History), to be preserved in the Geological Department.

V.—An exposure of Quartzite and Syenitic Rock near Martley, Worcestershire.

By Charles St. Arnaud Coles.

THE section in which these rocks are exposed is seen in a field at a distance of about a quarter of a mile from the village of Martley and due north of Berrow Hill Farm. Here is a small excavation for roadstone, but it does not appear to have been worked lately. Both the quartzite and syenitic rock are exposed, the latter being very decomposed. The relations of the rocks to one another appear to be as follows (see Figure) :—Below, at A, the quartzite is seen to stand out conspicuously. Round this, as at B, is a thin layer of powdery rotten rock, differing but little from the rest of the decomposed syenite, forming a crust at C, but evidently marking the junction of the quartzite and syenite; the latter being at D and E sufficiently undecomposed to allow of its being sliced. Above comes a loose breccia consisting of fragments of these rocks, but this is evidently surface soil.



Syenitic Rock-exposure, near Martley, Worcestershire.

Diagrammatic section brought to one plane. A = Quartzite; B, C = Decomposed Syenite, that at C forming a slope; D, E = Undecomposed Syenite; F = surface soil.

This section appears to correspond in position with that noticed by Professor Phillips ("On the Malvern and Abberley Hills," p. 8). However, no quartzite is mentioned by him, and the Old Red, Coal-measures, and Trias figured by him are not now visible. It seems probable, therefore, that the old excavation has been filled in, and that the present one has been worked to a greater depth, owing, most likely, to the discovery of the hard quartzite. A careful examination of the two rocks shows that their apparent relation, as mentioned above, in all probability is not the real one.

The syenitic rock, as has been mentioned, is very decomposed, but two specimens have been sliced. The structure is holocrystalline. Green mica and a felspar are the most prominent minerals, but there is also a little quartz. The felspar occurs in large, irregular, and fractured crystals, but is so kaolinized as to make it impossible to state with certainty whether it is plagioclase or orthoclase, but probably both are present. The mica is also much

decomposed and is partly replaced by chlorites and iron oxides; some of the latter mineral is, however, probably original, and appears to be titaniferous. The least altered biotite crystals form irregular wisps between those of the felspar. In this slice but little quartz is visible. There are also a few crystalline grains of a colourless silicate, with low polarization tints, one of which gives straight extinction. Possibly the mineral is zoisite. A second slice shows a larger quantity of quartz in the form of composite grains, probably due to fracture. Felspar and mica are present, as in the last slice, with the addition of a little hæmatite and one or two zircons. The rock is therefore a quartziferous mica-syenite or possibly diorite.

The rock obviously resembles the Malvern syenite. The similarity between the two has been noticed by Professor Phillips, and later by the Rev. W. S. Symonds ("Records of the Rocks," p. 37). Both these authors regard the rock at Martley as Malvernian in age; the former stating emphatically that it is not intrusive, and, in addition, that it differs from all other intrusive rocks in the neighbourhood. This syenite, so far as he could see, did not seem to have produced any alteration on the adjacent rocks.

The underlying quartzite exhibits a somewhat granular and saccharoidal structure. One specimen shows slickensides, another a very distinct and well-rounded pebble. On microscopic examination we find that the rock consists almost wholly of rounded grains of quartz, with a few fragments of decomposed felspar. One or two grains show a composite structure, as if derived from a schist. There are also clots of iron-oxide scattered about the slice. With crossed nicols each quartz grain is seen to be surrounded with a thin zone, evidently a secondary deposit. No strain shadows are visible, but dislocations are seen in parts of the field, and near them the grains are slightly crushed.

A second slice presents a very similar structure, but with a finer texture; the component grains not being so well rounded as in the last specimen. It shows no distinct signs of crushing, but is traversed by minute veins of quartz which occupy cracks.

The rock is therefore a quartzite with well-rounded grains, and is remarkably free from earthy matter. It is identical in every respect with that of the Lickey, and most probably belongs to the same geological age.

NOTICES OF MEMOIRS.

The Geological Survey of Great Britain and Ireland.

[Having, through the kindness of Sir A. Geikie, been favoured with an early copy of the Summary of Progress of the Geological Survey for the past year, and finding it to contain matter of much general interest to geologists, we are glad to give it a special notice in our present number.—Editor.]

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY FOR 1897. By Sir A. GEIKIE, D.Sc., D.C.L., LL.D., F.R.S., F.G.S., Director-General. 8vo; pp. 176. (London: Eyre & Spottiswoode, 1898. Price 1*s*.)

INTRODUCTION.

AS no official publication up to the present time has given an account of the origin, history, organization, methods, and aims of the Geological Survey of the United Kingdom, advantage is taken of the opportunity offered by the preparation of the present Summary of Progress to prefix an Introductory Section, in which these particulars may be specially set forth.

The objects for which the Geological Survey is carried on are of a twofold character, scientific and practical. It is charged with the preparation of a detailed map of the United Kingdom, in which the geological structure of every district is worked out, the boundaries and limits of the various rocks and superficial deposits are traced, and the outcrop of each important seam or vein is represented. Such a map forms the basis for an exact knowledge of the geology of the country, and is thus of fundamental value in the interests of pure science. It is also intimately connected with many of the most important questions of every-day life. Thus, by discriminating and delineating the different kinds of superficial deposits and subsoils, the map provides a basis for the solution of some of the chief problems in agriculture. It affords information which is absolutely necessary in questions of water-supply, drainage, and other sanitary matters. It supplies data required by the engineer in constructing roads and railways, by the architect in providing materials for new buildings, by the mining surveyor in determining the position of new pits and mines.

Besides preparing the map, the Geological Survey constructs detailed sections explanatory of the geological structure of the country; also memoirs descriptive of the geology of the districts represented on the sheets of the map, and larger monographs illustrative of the various geological formations of Britain. It collects specimens of the minerals, rocks, and fossils of each of the three kingdoms, arranges and describes them, and displays them to the public in the Museums in London, Edinburgh, and Dublin.

Besides its contributions to the progress of geology as a science, the Survey from the very beginning of its existence has kept in view the general utility of its operations. It has been constantly called upon by the various public Departments to furnish information in regard to the practical application of geology. The general public, also, has continually sought assistance of a similar kind. Each of the three offices in London, Edinburgh, and Dublin has become a centre of reference for information and advice on questions in which a knowledge of the geology of the country is requisite.

The following introductory pages contain (1) a brief narrative of the origin and progress of the Geological Survey and of the

Museum of Practical Geology, up to the present time; (2) a description of the various kinds of work carried on by the Survey in the field, in the office, and in the museum, with an account of the publications, issued and in preparation, by the establishment.

I. The Origin and History of the Survey and Museum.

The Geological Survey of the United Kingdom and the Museum of Practical Geology, Jermyn Street, owe their origin to Henry Thomas De la Beche—one of the most illustrious geologists of this century. After various geological researches prosecuted early in life on the Continent and in the South of England, he eventually undertook a more detailed examination of the rocks of Devon and Cornwall. Supplying himself with the maps of the Ordnance Survey, on the scale of one inch to a mile, he began to map the geological structure of that part of the country. This labour was carried on with his own hands and at his own charges. As it advanced, he was led to perceive that it might possess great public importance in regard to the development of the mineral resources of the kingdom. An accurate delineation of the courses of the mineral veins, coal-seams, and other useful substances contained among the rocks beneath the surface, and of the bearings of the faults that dislocate and shift them, could hardly fail to prove of much practical value as well as of scientific interest. After he had made some progress with his self-imposed task, De la Beche was induced to apply to the Government of the day for recognition and assistance. The Ordnance Survey, indeed, under the enlightened supervision of Colonel Colby, had already encouraged the surveyors of its staff to keep a record of their observations respecting the relations between variations in the topography of the land and changes in the characters of the rocks underneath. In this manner the geology of the district around Ludlow, together with that of the Forest of Dean and the central parts of Herefordshire, had been with more or less precision traced upon the Ordnance sheets.[1] De la Beche represented to the authorities that the work on which he was engaged would be much more efficiently carried out if it were conjoined with that of the general trigonometrical survey of the whole country, which was then in progress. His views were eventually approved of, and in the year 1832 he was appointed by the Board of Ordnance to affix geological colours to the maps of Devonshire, with portions of Somerset, Dorset, and Cornwall. By the Spring of 1834 he was able to publish four sheets of the geological map of the county of Devon, whereon the general geological structure was depicted with a minuteness and beauty of execution such as had not before been equalled. Three additional sheets of the Ordnance Survey were completed by the end of that year, while another was nearly finished.[2]

This rapid progress and the obvious advantages to be derived from the maps led to a more definite recognition of De la Beche's

[1] Proc. Geol. Soc., vol. i, p. 447.
[2] Op. cit., vol. ii, p. 154.

labours. In the Spring of 1835 the Master-General and Board of Ordnance consulted the Professors of Geology in the Universities of Oxford and Cambridge (Buckland and Sedgwick) and the President of the Geological Society (Lyell), as to the expediency of combining a geological examination of the English counties with the geographical survey then in progress. Supported by the strongly expressed approval of these distinguished men, the Treasury agreed to place on the estimates a grant "to defray the additional expense which will be incurred in colouring geologically the Ordnance county maps."[1] As the sum thus granted amounted to only £300 a year, most of the expense of the mapping still fell upon De la Beche himself. He also undertook the lion's share of the field-surveys, though he had the occasional assistance of some of the Ordnance surveyors who possessed geological experience. But he had gained the first and fundamental object which he had in view. His enterprise was officially recognized as a national Geological Survey, of which he himself became Director.

But De la Beche's bold and far-seeing mind had conceived a much more extensive scheme than the preparation of a geological map, and as soon as he felt himself secure in his first step he proceeded to take the next. In the Summer of 1835 he submitted to the Government a proposal that the exceptional opportunities enjoyed by himself and his staff to collect specimens illustrative of the applications of geology to the useful purposes of life should be taken advantage of, and that such collections, displaying the mineral resources of the country, should be placed in a room or rooms under the Board of Public Works. His plans being eventually accepted, rooms were assigned to him for the accommodation of the Survey collections in Craig's Court, Charing Cross, and he was asked to carry out his scheme under the control of the Office of Woods and Forests. Besides the extensive series of specimens gathered together during the mapping of Devon and Cornwall, there was another large assemblage of samples of British building-stones which had been collected by the Commission (whereof De la Beche was a member) appointed to inquire into the most suitable materials for rebuilding the new Palace of Westminster after the burning of the old Houses of Parliament in 1834. The specimens thus accumulated were arranged by De la Beche with reference to the instruction of the public, in illustration of the mineral resources of the country. Materials for making roads, for the construction of public works or buildings, for useful or ornamental purposes in the arts, for the preparation of metals, were grouped in such a way and with such explanatory labels, maps, models, diagrams, and sections, as to convey a large amount of useful information in the most compact and accessible form. In this manner the Museum of Practical Geology took its rise. The collections were in fair working order by the year 1839, though not ready to be opened to the public for two years later. De la Beche was appointed

[1] Proc. Geol. Soc., vol. ii, p. 358.

Director, an office which for some years he filled gratuitously. The infant museum was in charge of the Office of Woods and Forests, but the Geological Survey still remained under the Board of Ordnance.[1]

A further part of the Director's wide-reaching scheme was soon put into execution in the premises at Craig's Court. He had planned that besides obtaining information from specimens, models, diagrams, and maps, the public should be enabled at a moderate cost to procure analyses of rocks, minerals, and soils from the establishment under his control. He was authorized to fit up a laboratory and to appoint as Curator of the Museum one of the ablest analytical chemists of his time, Richard Phillips. He likewise procured the sanction of the Office of Woods for the institution of lectures, having for their object the illustration of the applications of geology and of its associated sciences to the useful purposes of life. Owing to the want of a suitable theatre and other appliances the design of providing lectures could not be carried into execution for twelve years. But eventually in the Autumn of 1851, when the building in Jermyn Street was inaugurated, De la Beche's scheme was carried out by the opening of the School of Mines.[2]

There was one further department which owes its foundation to the indomitable energy of De la Beche. In 1838 the British Association had memorialized the Government to take steps to collect and preserve all plans recording the mining operations of the United Kingdom, inasmuch as great loss of life and destruction of property had arisen from the want of the proper preservation of such documents. The Director of the Geological Survey was accordingly authorized to form a Mining Record Office as part of his establishment at Craig's Court. This new undertaking started in 1840, under the charge of T. B. Jordan, who was succeeded in 1845 by Robert Hunt. A large series of mining plans was gradually accumulated, and a yearly volume was issued embodying the statistics of the mineral industries of the United Kingdom. These statistics were obtained from the information voluntarily supplied by the proprietors, lessees, and others. Eventually, however, an Act of Parliament compelled the mine-owners to furnish the statistics to the Inspectors of Mines, who published them in their Report to the Home Office. As it thus became unnecessary that two similar returns should be published, and as it seemed desirable that the work of the Mining Record Office should be brought into closer relations with the Inspectors of Mines,

[1] Account of the Museum of Economic Geology, by T. Sopwith, 1843; Buckland, Proc. Geol. Soc., vol. iii, pp. 211, 221; Life of A. C. Ramsay, p. 39.

[2] The School of Mines continued to form part of the Jermyn Street establishment for more than twenty years. The progress of scientific education in that interval, however, demanded more space for practical instruction than the building could supply. Accordingly, in 1872, the departments of chemistry, physics, and biology were transferred to more commodious quarters erected by the Science and Art Department at South Kensington, and the other departments were similarly transferred as space could be provided for them. The last Professor at Jermyn Street was the late Warington W. Smyth, on whose death, in 1890, the mining instruction was also removed to South Kensington.

that office was in the year 1883 transferred to the Home Office, under which the Inspectors serve.

We may now trace briefly the progress of the Geological Survey from its commencement to the present time. As above stated, it was begun as a private enterprise by De la Beche previous to the year 1832, and was first established as a branch of the Ordnance Survey in 1835. Ten years afterwards, in 1845, the staff was considerably increased, and the Survey was transferred from the Board of Ordnance to the "Office of Woods and Works," so that the whole of the geological organization, including the Survey, Museum, and Mining Record Office, was thus united in one Government Department, under De la Beche as Director-General. The Survey, which had hitherto been that of Great Britain, now became that of the United Kingdom. The staff in England and Wales was placed under A. C. Ramsay, as Director for Great Britain, while a small force was placed in Ireland, in charge of Henry James, R.E.

The Great Exhibition of 1851 led to the establishment in 1853 of a Department of Science and Art, under the Board of Trade, to which the Jermyn Street organization was transferred. In 1856 this Department was placed under the control of the Lords of the Committee of Privy Council on Education, and this arrangement has continued up to the present time.

By the time the Geological Survey was transferred in 1854 to the Science and Art Department, great progress had been made in the mapping of England and Ireland. The survey of the whole of Wales had been completed and published, and the field-work was advancing eastwards into the central counties of England. In Ireland, the maps of the counties of Dublin, Kildare, Wicklow, Carlow, Wexford, Kilkenny, Waterford, and almost all Cork had been completed, and the field-work was being pushed into King's County and Queen's County, and across Kerry and Limerick. In the same year, 1854, the operations of the Survey were extended into Scotland, where A. C. Ramsay broke ground in East Lothian.

Up to this time the field-work of the staff in England and Wales had been conducted upon the basis of the Ordnance maps on the scale of one inch to a mile, no larger scale being available. In Ireland, however, maps on the scale of six inches to a mile had been published by the Ordnance Survey, and these from the beginning were adopted as the groundwork of the Geological Survey. Maps on this larger scale were available also in Scotland, and were from the first made use of for geological purposes. As the Geological Survey advanced northwards in England, it found the six northern counties mapped on the six-inch scale, and at once adopted this larger scale as the basis of the field-work.

As the great advantages of the use of the larger scale came to be recognized in practice, it was found that the superficial accumulations could be expressed on this scale without unduly interfering with the delineation of the structure of the rocks underneath. At the same time, increased attention was now being paid to the drifts which had been so long neglected. Their paramount

importance in relation to soils had long been recognized, but their great geological interest as records of the Glacial Period was more gradually perceived. As the possession of a detailed topographical map now enabled the surveyors to trace the superficial accumulations with a precision quite unattainable on the old one-inch sheets, it was determined to delineate the distribution of these surface-deposits at the same time that the boundaries of the underlying rocks were being followed. Hence in the six northern counties of England, Scotland, and thenceforth everywhere in Ireland, the drifts were distinguished and expressed upon the six-inch maps.

The great practical and scientific advantages of carefully mapping the superficial deposits on a large scale were amply shown by the experience of a few years. It was found, however, that the tracing of the distribution of the various kinds of Drift greatly increased the amount of labour entailed in the preparation of the general map of the country, thus necessarily diminishing the area surveyed each year and reducing the rate of progress of the Survey. At last, in 1867, a great increase was made in the strength of the staff, which was also reorganized with a view to greater efficiency. A distinct branch of the service was established for Scotland under a separate Director (A. Geikie), the English branch remaining under the supervision of A. C. Ramsay, and the Irish under J. B. Jukes, while Sir R. I. Murchison, who had succeeded De la Beche in 1855, continued Director-General of the whole.

At this important epoch in the history of its organization, the Survey of England and Wales had completed and published the maps of the country as far north as a line drawn from Liverpool to Selby, and as far east as Retford, Melton Mowbray, Market Harborough, Huntingdon, London, Chatham, and Folkestone. Considerable progress had been made with the mapping of the north of Lancashire and Westmoreland, and a portion of the great Northumberland Coalfield had been surveyed. In Ireland the maps of the larger half of the island had been published, and the field-work had been pushed northwards to a line drawn from Castlebar to Drogheda. In Scotland, where the staff had always been disproportionately small, the maps of the basin of the Forth had been completed from the north of Fife to Berwick-on-Tweed. The backward state of the Ordnance Survey had necessitated the transference of the staff to the west side of the country, where six-inch maps were available, and some progress had been made with the examination of the south of Ayrshire.

The whole energy of the staff was now directed to the completion, as quickly as possible, of the one-inch map of each of the three kingdoms. That of England and Wales was finished in 1883, and that of Ireland in 1887. The completion of these maps liberated some of the officers in England and in Ireland, who were accordingly transferred to the Scottish staff. As the Survey of Scotland was commenced long after that of the sister kingdoms, and was carried on for many years by a staff of only two surveyors, it is not yet completed. At the present time the unsurveyed portions of the

country include the central mountains of Sutherland and Ross, with most of Inverness-shire, the western parts of Argyllshire, and most of the Western Isles.

When the one-inch map of England was completed, most of the staff was detailed for the purpose of mapping the superficial deposits in the southern half of the kingdom, and thus providing materials for a complete agronomic map of the whole of Britain. An opportunity has at the same time been afforded to revise the published maps and bring them up to date. The nature and extent of this revision will be more particularly noticed in subsequent pages. When the one-inch map of Ireland was finished the staff was reduced, partly by transference to Scotland and partly by retirement, only such a number of officers being retained as might suffice for the necessary revisions which the progress of time requires. To these revisions also fuller reference will be made in the sequel.

II. The Work of the Geological Survey.

The combined scientific and practical objects which De la Beche set before himself as his great aim at the first institution of the Geological Survey, have ever since been kept steadily in view. To this day the development of the mineral fields of the country by means of accurate maps, the collection of data for the guidance of those in search of water-supply, the accumulation of information required for the purposes of agriculture, engineering, road-making, architecture—these and many other applications of geology to the arts, manufactures, and practical affairs of our social life continue to form a large part of the work of the Survey. But, as De la Beche and his early associates clearly recognized from the beginning, all such utilitarian uses of geology must be based on a thoroughly systematic examination of the geological structure of the country. So closely are pure science and industrial progress linked together, that at any moment what might be supposed to be a matter of merely theoretical import may be discovered to have a high practical significance and value. Hence the Geological Survey has been conducted as a strictly scientific investigation, and has thus been able to advance the interests of geological science. The geological structure of the British Isles has been traced out in greater detail than was before attempted in any country, and numerous additions have thereby been made to the general body of geological knowledge.

1. Field Work.[1]—The first and most important duty of the Survey is to map in detail the geological structure of the country. When this task was first undertaken by De la Beche the Ordnance Survey maps on the scale of one inch to a mile ($\frac{1}{63360}$) which had then been published for some of the southern counties of England, and which he used as the basis of his work, were imperfect and incorrect in their topography. They were among the first undertakings of the Ordnance Survey, before methods of surveying had

[1] Some portions of the following account of the work of the Geological Survey are taken from a paper communicated by the Director-General to the Federated Institution of Mining Engineers. See their Transactions, vol. v (1893), p. 142.

been brought to the perfection that has since been attained. The possession of a correct topographical map is absolutely necessary as the groundwork of a detailed and accurate geological survey. From the outset the Ordnance maps have afforded the topographical groundwork on which all the geological surveying has been carried on. For many years only the sheets of the general map on the one-inch scale were available, but when, in the progress of the Ordnance Survey, maps on larger scales were prepared, these, as already remarked, were employed for geological purposes.

All the mapping of the Geological Survey is now conducted upon the Ordnance maps on the scale of six inches to one mile ($\frac{1}{10\frac{1}{560}}$), as has been above remarked. These maps were not available in England and Wales until about two-thirds of the country had been surveyed geologically, and it was only in the six northern counties that they could be adopted. In Ireland, however, and in Scotland, where they were obtainable from the commencement of the geological operations, the whole of the work has been conducted upon them.

It is impossible to overestimate the gain, both in completeness and accuracy, from the substitution of a large-scale map in the general investigation of a complicated geological region. Not only is it then much easier to fix the position of geological boundaries, but an amount of detail may be inserted for which, though of great importance, no room can be found on the one-inch scale. The large map serves at once as a map and a notebook, and numerous detailed observations can be taken and recorded upon it at the localities at which they are made.

Occasionally, where the geological structure becomes excessively complicated, and requires to be mapped out in much detail, maps on the scale of 25 inches to a mile ($\frac{1}{25\frac{1}{340}}$) are made use of. Ultimately, however, all the work is reduced to the one-inch scale, this being the scale on which the general geological map of the United Kingdom is published.

Geologists had made considerable progress in the study of the solid rocks before much attention was paid to the looser superficial deposits. The Geological Survey in this respect followed the general rule, and for many years made no systematic attempt to represent the numerous and often complex accumulations of superficial materials. Some of these, indeed, were shown on the maps, such as tracts of blown sand and river-alluvium. But it must be remembered that in the south-western counties, where the Geological Survey began its work, superficial deposits are of such trifling extent and importance that they were not unnaturally ignored. Only after most of the southern half of England had been completed was it determined to map the surface-deposits with as much care and detail as had been expended on the older formations lying beneath them. It had been discovered that this course was necessary both on scientific and practical grounds. In the first place, these superficial accumulations contained the records of the later geological vicissitudes of Britain, and were beginning to reveal a story of the profoundest interest, inasmuch as it dovetailed with the history of the human

occupation of the country. In the second place, it was recognized that in many various ways these surface-deposits had a direct and vital influence upon the welfare of the population. In agriculture, in water-supply, in questions of drainage, and of the location of dwellings, it was seen that a knowledge of the soils and subsoils, and of the formations from which these are derived, was of the utmost practical importance. It was therefore determined that henceforth the Geological Survey should not only pourtray the lineaments of the solid earth, but trace out the drifts and other surface-deposits which, like a garment, overspread and conceal them. It was impossible at first to go back over the ground where the surface-geology had been omitted. But it was arranged that when the whole country had once been mapped those tracts should be re-examined wherein the superficial deposits had not been surveyed. And, in the meantime, over all new areas the survey was made complete by tracing out simultaneously both the surface-deposits and the older rocks below them.

The Drift Survey of Wales, and of those parts of England where the superficial deposits were not originally mapped, now occupies the time of a considerable part of the English staff. In Ireland, also, those tracts where the peat and some other superficial deposits were not delineated are now having this omission remedied. In Scotland the drifts are all mapped at the same time with the rest of the geology.

As an illustration of the detail into which the mapping in this department has been carried, it may be mentioned that under the single term "alluvium" we now discriminate and indicate by separate signs and colours a large number of distinct deposits. Thus, there is a group of fresh-water alluvia, beginning with the present flood-plains of the rivers and rising by successive terraces to the highest and oldest fluviatile platforms. Deposits of peat are separately traced, and tracts of blown sand are likewise mapped. Another series, consisting of marine alluvia, ranges in position and age from the mud of modern estuaries and the sands of flat shores exposed at low water, through a succession of storm-beaches and raised beaches, up to the highest and most ancient marine terraces 100 feet or more above the present level of the sea. Regarding the origin of some of the high-level gravels, there is still much uncertainty, but the Survey has taken the first necessary step for their ultimate explanation by carefully tracing their distribution on the ground.

But the most abundant and complex group of superficial deposits is that which may be classed under the old name of Glacial Drifts. These have been mapped by the Survey in detail, and much of the progress of glacial geology in this country has been due to the sedulous investigation thus required. The ice-striæ on the solid rocks have been observed over so much of the country, that maps may now be constructed to show both the march of the main ice-sheets and the positions of the later valley-glaciers. The various boulder-clays have been mapped, likewise the sands and gravels.

The survey of the superficial deposits thus combines a wealth of geological interest with a great deal of practical value. The geologist may find in it the solution of some problems and the presentation of many more; while the farmer, the water-engineer, the builder, the road-maker, and the sanitary inspector may each in turn gain practical information from it for his guidance.

For purposes of distinction, the mapping of the formations of every age that lie beneath the recent superficial deposits is known in the Survey by the somewhat unhappily selected epithet of the "solid geology." The object in this part of the field-work is to represent on the maps the exact area which every formation or group of rocks occupies at the surface, or immediately below the soil and drift, together with all indications that can be obtained of its structure, such as its variations of inclination, its changes of lithological character, and the dislocations by which its outcrop is affected. While the basis of the work is rigorously geological, facts having an industrial bearing, such as the presence of useful minerals, or the depth and variations in thickness of water-bearing strata, are observed and recorded.

In those districts of the country where the rocks have long been well known and where the geological structure is simple, the duties of the surveyor are comparatively light, though it often happens there that the simplicity of the "solid geology" is compensated for by a great complexity in the overlying "drifts." Where, on the other hand, the rocks are varied in character and complicated in structure, where they are partially hidden under superficial deposits, and where they rise into mountainous ground, difficult of access and hard to traverse, geological surveying becomes a most laborious occupation. In such a region as that of the North-West Highlands of Scotland, for example, where the physical impediments are great, where the ground is often both rugged and lofty, where the climate is wetter and more boisterous than almost anywhere else in Britain, and where the quarters to be had are often sorry enough and remote from the scene of work, the surveyor has need of all his enthusiasm to carry him bravely through these preliminary obstacles. But when he comes to unravel the structure of the rocks, he may find it to be sometimes almost incredibly complex. He has to climb the same cliff, scour the same crag, and trudge over the same moor again and again before he begins to perceive any solution to the problems he has to solve.

If the complicated "solid geology" of such a region is enough to tax to the utmost the capacity and energy of the geologist, his task is made still more difficult by the necessity of keeping his eye at the same time ever open to all the variations of the superficial deposits, which in these rugged tracts are often singularly intricate, though they may also be fascinatingly interesting. The ice-striæ on the rocks, the scratched stones high on the mountain-sides that mark where the till once lay, the varieties of boulder-clay, the sand and gravel eskers, the scattered erratic blocks and the detection of their probable sources of origin, the moraine-mounds fringing or

filling the bottom of the glens, the sheets of flow-peat and the ragged peaty mantle that hangs down from the cols and smoother ridges, the recent alluvia and the successive stream-terraces, the lines of raised beach and the estuarine silts—all these and more must be noted as the surveyor moves along, and must be duly chronicled on his map and among his notes.

It is obvious that the progress of the mapping in such ground cannot be rapid. If the work is worth doing at all, it should be well done, and if well done, it must be done slowly and carefully. It is evident also that the total area surveyed in a year, if given in square miles, affords no guidance whatever as to the amount of labour involved. There may be a hundredfold more exertion, physical and mental, required to complete a single square mile in some districts than to fill in twenty square miles in others. It is customary in the Survey to estimate not only the area annually mapped by each officer in square miles, but also the number of miles of boundary-line which he has traced. The ratio between these two figures affords some measure, though an imperfect one, of the comparative complexity or simplicity of the work. In simple ground a surveyor need have no difficulty in mapping from 70 to 100 square miles in a year, each square mile including from 3 to 6 linear miles of boundary. But in more mountainous and difficult districts it may be impossible to accomplish half of that amount of area. In these cases, however, the ratio between area and boundary-lines usually rises to a high proportion. Thus, in the Scottish Highlands the average number of linear miles of boundary-lines sometimes rises to as much as 17 miles in every square mile surveyed.

In mining districts an endeavour is made to express on the maps the positions of the outcrops of all seams and lodes, the line of every important fault and dyke, with the place of such faults at the surface, and where they cut different seams underground. The information necessary to record these data is mainly furnished by the owners and lessees of the mines and pits, who, as a rule, most generously give the Survey every assistance. Details as far as possible are inserted on the six-inch Ordnance sheets. Copies are taken of borings and pit sections, and notes are made regarding variations in the character of the seams or lodes from one part of a mineral field to another. At the same time, the district is surveyed in the usual way, and by exhausting the surface-evidence the surveyor is not infrequently able to supply important additional information beyond what can be obtained from the mining-plans.

It is the necessary fate of all geological maps to become antiquated. For, in the first place, the science is continually advancing, and the systems of arrangement of the rocks of the earth's crust are undergoing constant improvement, so that the methods of mapping which satisfied all the requirements of science thirty years ago are found to be susceptible of modification now. In the second place, in the progress of civilization, new openings are continually being made in the ground: wells, roads, drains, railways, and

buildings are being constructed, whereby fresh light is obtained as to the rocks below. Geological lines which were traced with the imperfect evidence formerly available can thus be corrected, and new lines which perhaps were not originally suspected can be inserted. If this kind of obsoleteness overtakes geological maps even where only superficial openings are concerned, still more does it affect those which depict the structure of mineral-fields still actively worked. The geological maps of Devon, Cornwall, and South Wales, made some two generations ago by De la Beche and his associates, were for their time admirable in conception and excellent in execution. Nothing approaching to them in merit had then been produced in any part of the world. But the mineral industry of the country has not been standing still all these years. Enormous progress has been made in working the ores of the western counties, and in developing the great South Wales Coalfield. Yet most of the maps still remain as they were originally published, though their revision is now in progress.

It is absolutely necessary, if the value of the labour and expense bestowed on the Geological Survey of the United Kingdom is not to be impaired and lost, that the maps should be revised and brought up to date as frequently as may be required. The necessity for such revision has been pressed on the attention of Government by influential memorials from various districts of the country; and, hitherto, as far as the other requirements of the Survey permit, these requests have been complied with. Thus, in consequence of an urgent representation from the proprietors and lessees of the coalfield of South Wales, and from others locally interested in the development of that region, steps were taken a few years ago to place there a staff of surveyors, and the revision of the ground is actively advancing. Already three sheets of the new series of Ordnance Maps of South Wales have been published, and one other is now in the hands of the engraver. The inhabitants of Cornwall, likewise, recently memorialized the Science and Art Department to undertake a revision of the geological maps of that county; and, in response to their request, a beginning of the work has been started. The people of North Staffordshire, anxious for the proper development of their coalfield, made a representation that the time had come when a revision of the maps of their district was necessary, and this task has been undertaken by the Geological Survey. Other districts have sent in similar petitions for re-survey with which it has been hitherto impossible to comply, owing to the smallness of the staff. All these tracts of country were originally surveyed on the old and imperfect sheets of the one-inch Ordnance map. But the revisions are conducted on the modern six-inch scale, and the reductions are made upon the new series of one-inch sheets. There can be no doubt that all the other mineral-fields of the country require similar treatment.

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maps. While this revision is in progress advantage is taken of the re-examination of the ground to make any needful additions or modifications in the "solid geology." The work is reduced from the large field-maps to the new series of the one-inch map. Geological maps on the six-inch scale were formerly published for the mineral-fields, but are now no longer engraved, though a large number of sheets of the coalfields are on sale. But manuscript copies of six-inch maps relating to any parts of the country of which the one-inch sheets are published, are supplied to the public at the cost of manual transcription.

While the field-work is in progress the surveyors collect, for the purposes of their maps and explanatory memoirs, such specimens of minerals, rocks, and fossils as may be found to require special examination. But a more systematic collection is carried out under their supervision by the collectors, for study by the petrographers and palæontologists and for exhibition in the museums. Each branch of the Survey has one or two collectors, who move from district to district as their services are required. When one of them begins work in any area, he is supplied with a map on which the field-officer who surveyed it has marked every locality that should be searched, and also with a list of these localities, giving local details as to the rocks to be specially searched or examined, and the kind of specimens to be looked for and collected. When necessary, the surveyor accompanies the collector to the ground and starts him on his duties. Every specimen which the collector sends up to the office has a number affixed to it, and is entered in the lists, which are also at the same time transmitted to headquarters. The specimens are then unpacked and treated by the palæontologists or petrographers, as the case may be. In this manner a remarkably complete illustration of the geology of the United Kingdom has been accumulated by the Survey, and it is constantly receiving additions and improvements. The chief series is deposited in the Museum of Practical Geology, London; but the geology of Scotland is most fully represented in the Museum of Science and Art in Edinburgh, and that of Ireland in the corresponding Museum at Dublin.

(*To be continued.*)

REVIEWS.

I.—Wachsmuth and Springer's Monograph on Crinoids.[1]

Second Notice.

BEFORE entering on the discussion of morphological questions, the authors very properly define the terms they propose to use. Since all these terms will be familiar to those who have followed the papers of Messrs. Wachsmuth and Springer, P. H. Carpenter, and myself, only a few remarks are needed.

[1] The North American Crinoidea Camerata. By C. Wachsmuth and F. Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897.) For First Notice, see June Number, p. 276.

It is stated on p. 32 that this terminology is the result of correspondence with P. H. Carpenter, and that "Mr. F. A. Bather, in 1890, also agreed to accept this terminology with very slight modifications, and applied it practically in his earlier descriptions of British fossil Crinoids, but renounced it in 1892, and proposed in its place a new one." To remove the misapprehension to which such a presentment of the case must give rise, it may be stated that the scheme of terminology in question includes 86 terms; of these I have formally renounced seven, while I constantly use all the rest with perhaps three exceptions, and five of the terms were actually proposed by me. I am glad to be in better accord with the American authors than they have been ware of.

The expressions 'stem-joints' and 'arm-joints' are in common use, no doubt; but this extension of the word 'joint' to the segments separated by the joint, however admissible in the kitchen, should not pass into scientific terminology, which should be, above all things, precise and unambiguous. The arm-ossicles are now generally called 'brachials'; the stem-ossicles may well be termed 'columnals,' and the cirrus-ossicles 'cirrals.' As a natural consequence of this loose use of the word 'joint,' we find Messrs. Wachsmuth and Springer applying the term 'syzygy' to the brachials united by a rigid suture, rather than to the suture itself. Such a usage is common, but that it is incorrect and unscientific I have already shown[1] to the satisfaction of several leading writers on crinoids, and among them Mr. Springer. As noted on p. 81 of the monograph, "the term 'syzygy' has also been used by some writers for the immovable union of the nodal stem-joints with those next below them"; and to this use Messrs. Wachsmuth and Springer object. It is true that the word was not used in this sense by Müller, who seems to have overlooked the structures in question, and it is equally true that "radiated and dotted surfaces do not always imply a 'syzygy'"; still, Müller's definition is phrased in quite general terms and not necessarily restricted to brachials, so that in it there is nothing inconsistent with the extension to columnals. Such extension leads to no ambiguity and saves the invention of yet another set of terms.[2]

The term 'centrodorsal' is a never-ending source of trouble. Our authors naturally do not confuse it with the absurdly-named 'dorso-central,' but they apply it to "the plate within the infrabasal ring of the Marsupitidae." Now 'centrodorsal' is the name of that element in the skeleton of an Antedonid which is composed of the infrabasals and the proximal columnal or columnals fused into a solid cirriferous ossicle. We do not know the true relationships of the plate at the aboral pole of *Marsupites*, but we know that it does not comprise infrabasals and does not bear cirri. For this reason I have proposed for it and for the similar plates in *Uintacrinus* and *Saccocoma* the non-committal term 'centrale.'[3]

[1] "The term 'syzygy,' etc.": *Zool. Anzeiger*, xix, pp. 57–61, Feb. 3, 1896.
[2] See P. H. Carpenter, "'Challenger' Report on Stalked Crinoids," p. 4, 1884.
[3] "On *Uintacrinus*": *Proc. Zool. Soc. London*, vol. for 1895, p. 997; 1896.

The columnal that remains throughout life at the proximal end of the stem in the Ichthyocrinidæ and their allies, as well as in the Apiocrinidæ and their allies, may also fuse with the infrabasals, but is in other respects hardly comparable with a true centrodorsal, though often called by that name; it is therefore convenient to distinguish this as the 'proximale.'[1]

The tegmen, or ventral covering of the calyx, consists of orals, ambulacrals, and interambulacrals. Through some portion or other of the tegmen there are pores, which place the outer water in communication with the body-cavity, and so, indirectly, with the water-vascular system. In most recent crinoids these pores are scattered over the tegminal surface and penetrate the plates of which it is composed. According to the work before us (p. 35), "the perforated plates have received the name *an-ambulacrals*." This does not represent fairly the accepted use of the word 'anambulacral,' and is sure to perplex the beginner. The term was invented by Joh. Müller, who applied it primarily to the above-mentioned water-pores, to distinguish them from the ambulacral pores for tube-feet (podia). The term has, however, been extended not merely to the plates pierced by the pores, but to the remaining imperforate plates of the tegmen other than ambulacrals or covering-plates and adambulacrals or side-plates.[2] In fact, rightly or wrongly, 'anambulacral' is nowadays a synonym of the less ambiguous 'interambulacral,' and should either be dropped or redefined in the strict Müllerian sense. It cannot well be extended to all perforate plates, for some of these may be actual brachial elements.

The term 'adambulacral' has just been mentioned. Messrs. Wachsmuth and Springer write (p. 36): "The *ambulacral plates* consist of the *ad-ambulacral* or *side-pieces*, and the *covering plates*, or *Saumplättchen*; the former, when present, constitute the outer, the latter the inner rows of the plates." It seems to me more precise and more in accordance with the use in other Classes of the Echinoderma, to restrict the term 'ambulacralia' to the alternating covering-plates, and not to widen its connotation so as to include adambulacralia. It must be admitted, however, that it is often hard to distinguish side-plates from covering-plates, owing in some cases to the compound structure of the latter, in other cases to their partial or complete atrophy.

The use of the word 'ambulacra' also appears to me highly incorrect. "The *ambulacra*," we are told (pp. 35, 36), "diverge from the mouth to the tips of the rays, following the ventral furrows of arms and pinnules. When subtegminal, they enter the calyx by means of the *ambulacral* or *arm openings* at the upper edge of the dorsal cup; when tegminal, they follow the surface of the disk. They contain the *food-groove*, the *ambulacral vessels*, the *ovarian tube*, and the *axial canal*. The *food-groove* forms the upper passage.

[1] First proposed in F. A. Bather, "Wachsmuth and Springer's Classification, etc.": *Natural Science*, xii, p. 341, May, 1898.

[2] P. H. Carpenter, "'Challenger' Rep. Stalked Crinoids," p. 76, 1884.

It is followed in descending order by the *subtentacular* canal, the *genital* canal, and the *axial* canal." Now the majority of the structures herein mentioned have nothing to do with ambulacra, which are here, as in all Echinoderma, radial extensions from the circum-oral water-vessel, giving off lateral branches, the podia (tentacles of crinoids, tube-feet of sea-urchins). Each ambulacrum may be accompanied by radial extensions of other systems of the body—or it may not. In a crinoid the ambulacra pass to the tips of the arms, so also do the radial extensions of the superficial oral nervous system, the paired cords of the deeper oral nervous system, and the pseudhæmal canal, none of which structures are mentioned by Wachsmuth and Springer. Those that they do mention are not quite happily introduced, for there are two subtentacular canals, as well as another extension from the body-cavity, unpaired and lying dorsal to the genital canal. The genital canal contains the genital rachis, which may be an "ovarian tube" or may be of male nature. Finally, the reader must not infer, as he might easily do, from the above-quoted description, that the axial canal with its contained axial cord accompanies the ambulacrum in its tegminal or subtegminal passage towards the mouth; it separates from it immediately on reaching the walls of the calyx, and while the ambulacrum passes along the ventral surface, the axial cord passes down the dorsal walls to the aborally situate chambered organ. Of course Messrs. Wachsmuth and Springer knew the above facts long before I wrote a line on the crinoids; but it is just because of their learning and authority that these lapses and ambiguities are so misleading to the student, for whose benefit the chapter is intended.

To the paragraph defining the term 'perisomic plates' (foot of p. 36) I turned with interest, because in 1891 these same authors published an important paper on "The Perisomic Plates of the Crinoids," [1] which I have read and reread without discovering what they meant by 'perisomic' or why they used the word. Moreover, the term has been a rock of offence to others, notably Dr. Arnold Lang, as I ventured to point out in a review [2] of the section on echinoderms in his valuable text-book. It is doubtful whether we shall be greatly helped by the present definition: "The term *perisomic plates* is given to all plates which are originally developed from simple, cribriform films of limestone. They comprise the interradials and interaxillaries, the anals, and all ambulacral and interambulacral plates." Of course the definition would "comprise" a good many other plates, such as basals, radials, and orals, but it is still doubtful whether this is the intention of the authors. In some respects the definition approaches that of Wyville Thomson, who first used the term; but he did not include the radials in his

[1] *Proc. Acad. Nat. Sci. Philadelphia*, vol. for 1890, pp. 345–392, pls. ix, x. Reviewed in GEOL. MAG., Dec. III, Vol. VIII, pp. 219–224, May, 1891.

[2] "The text-book writer among the echinoderms": *Natural Science*, vi, pp. 415–423, June, 1895.

"perisomatic system." W. B. Carpenter rightly attached "but little importance to the form of the reticulation as a differential character"; he was "disposed to regard the perforation or non-perforation by the radiating extensions of the Crinoidal axis [axial nerve-cords] as quite sufficient in itself to differentiate the entire skeleton into two series of plates."[1] To some extent this division corresponds with Wachsmuth and Springer's division into primary and secondary; but since they include the ambulacrals among primary plates (p. 38), it is clear that their 'perisomic' is not a synonym of their 'secondary.' Here, then, is a term used in a different sense by each writer in succession, apparently incapable of strict definition, and corresponding to no morphological idea. Why can we not bury it for good and all? This mighty monograph affords a fitting mausoleum.

In designating the different radii and interradii of the calyx, the anal interradius is of course 'posterior,' while the radius opposite is 'anterior'; in the natural position of the crinoid, the right and left sides correspond with the right and left of one observing the cup from its anal side. The radii adjoining the posterior interradius are naturally designated 'right and left posterior,' while the interradii adjoining the anterior radius are the 'right and left anterior.' I have called the radii next the anterior radius the 'right and left anterior'; and the interradii next the posterior interradius, the 'right and left posterior.' Messrs. Wachsmuth and Springer would substitute the appellations 'right and left antero-lateral' and 'right and left postero-lateral'[2] respectively. My mode of expression may be a tiny trifle less precise, but it is open to no misconstruction, since in a five-rayed symmetry only one radius can possibly be meant by 'right anterior'; moreover, it is three syllables shorter.

So far, it will have been seen, I have no quarrel with the terminology adopted by Messrs. Wachsmuth and Springer; I differ from them merely in the interpretation of a few of the terms, a matter in which their opinion (where it is a definitely stated opinion and not a loose mode of expression or a slip) is of at least as much value as mine. We come now to a case in which, after much epistolary discussion with my departed friends Carpenter and Wachsmuth, I decided to adopt a different and entirely new set of terms. This was in connection with the successive series of brachials. It seemed to me, as also to Carpenter, that the expressions "brachials of the first, second, or third, etc., order," and even "primary, secondary, or tertiary, etc., brachials," were too long and cumbrous. In their stead Carpenter proposed "costals, distichals, palmars, post-palmars, second post-palmars, third post-palmars, etc." These were accepted by Wachsmuth and Springer, and originally by me also. But I soon discovered that such an expression as "the third second post-palmar" was not merely cumbrous and inelegant, but also one involving (for me at least) a more serious effort of memory or of calculation than circumstances

[1] "Researches on the Structure . . . . of *Antedon rosaceus*": *Phil. Trans.*, 1866, p. 742.

[2] They have "antero-lateral" (p. 37), but it must be a misprint.

warranted. The terms were open to criticism on the following grounds: want of congruity *inter se*; previous uses of the word 'costal' in various other senses; difficulty of remembrance and of working, especially in the higher series; inadaptability to symbols, formulæ, and general statements. The truth of this criticism has never been contested, nor has any objection, other than on the ground of novelty, ever been raised to the series of terms and symbols proposed by me in their place, viz., Primibrachs (I Br), Secundibrachs (II Br), Tertibrachs (III Br), Quartibrachs (IV Br), and so on, along with which go the terms and symbols applied to the successive axillaries, Primaxil (I Ax), Secundaxil (II Ax), and so on. Had I confined myself to the above criticism, and to the proposal of this simple, congruous, easily remembered, and easily applied set of terms, it is probable that they would have met with more general acceptance than has been their lot. Unfortunately, I thought it necessary to draw attention to a morphological difficulty in the way of homologizing the series of a pinnulate arm with those of a non-pinnulate arm; and to avoid this I proposed, for pinnulate arms only, "a terminology congruous with the Müllerian term 'distichals,'" viz., monostichals, distichals, tetrastichals, octastichals, and so forth. To this latter terminology various objections either have been or might be raised. In the first place, the morphological difficulty, though still obvious to me, does not appear to present itself to Messrs. Wachsmuth and Springer. Secondly, the terms in their higher series, though rarely required, rapidly increase in cumbrousness. Thirdly, the branching of pinnulate arms is often so irregular as to falsify the terms, e.g., instead of their being four rami of the third order there may be only three, which therefore cannot correctly be called tetrastichals. Fourthly, the terms cannot be readily intelligible to the systematist, if he really is so devoid of classical culture and mathematical training as my critics maintain. For these reasons I do not propose to put into practice what has never been more than a suggestion. There are, I still believe, cases in which the distinction between pinnulate and non-pinnulate arms requires expression in the terminology and formulæ, and the term 'main-axil' is undoubtedly of great use. But for general purposes I, like Wachsmuth and Springer (p. 77), "see no good reason why the former terms [primibrachs, secundibrachs, etc.] could not be used for all Crinoids, pinnulate or non-pinnulate." It is greatly to be wished that all writers on crinoids should agree on this matter, and to that end I make this concession.

We turn now to the "Morphological Part."

This is almost confined to the morphology of the skeleton, and begins by dividing the skeletal elements into (*a*) primary and (*b*) secondary or supplementary, (*a*) being subdivided into (i) abactinal and (ii) actinal. These categories, established in the paper on "Perisomic Plates" above referred to, were explained to readers of the Geological Magazine in the review of that paper (May, 1891); they are

based on sound developmental principles, and conduce to a clear understanding of the variations in skeletal structure presented by the several Orders and Families.

The account of the Stem (pp. 38–58) has much value, not merely as a summary of known facts, but as introducing new details, and for the first time using the variations of this organ as factors in the main scheme of classification. The authors believe that the Crinoidea may be divided into two groups in accordance with the growth of the stem. In one group new columnals are developed next the cup, so that the top columnal is always one of the latest formed, and continually moves from its proximal position as new columnals develop. This group includes all genera which the authors assign to their Orders Inadunata and Camerata. In the other group the top-columnal is not the latest formed, but is a persistent 'proximale' (*vide* p. 320). This group includes the Ichthyocrinoidea of some previous classifications, the Apiocrinidæ, Bourgueticrinidæ (including *Rhizocrinus*), Antedonidæ and similar forms, Eugeniacrinidæ, and Holopodidæ; it is named 'Articulata' by Messrs. Wachsmuth and Springer, but, as I have elsewhere urged, Von Zittel's name of 'Flexibilia' is free from the variety of meanings under which the word Articulata labours. This grouping, according to stem-growth, is not made superior to the previously existing ordinal divisions; but so far as the definition of the Order Flexibilia is concerned, it affords a diagnostic character of importance. The systematist, however, though he may welcome such an aid, is bound to criticize with care the evidence on which it is proposed. In this case so slight is the attempt at proof that scepticism remains our only attitude. A student seeking a subject of research could not do better than investigate this question thoroughly.

As for the stem generally, it is obvious that a digested body of information, with reference to its characters in genera and species, would be of the utmost value to the stratigrapher, who finds thousands of stem-fragments, at present indeterminable, to one determinable crown. What are the prospects of our ever being able to determine genera and species from columnals alone? Among genera common in Neozoic rocks there are *Rhizocrinus*, *Bourgueticrinus*, *Acrochordocrinus*, and the Pentacrinidæ, which are pretty readily determinable; while in the highly specialized Pentacrininæ, at all events, the details of the stem are often characteristic of species. It is less easy to separate the genera and species of Encrinidæ, Apiocrinidæ, and Eugeniacrinidæ on these characters, although a few are fairly distinct (e.g., *Traumatocrinus*, *Millericrinus horridus*, *M. Charpyi*). Among Palæozoic genera the differentiation of the stem had as a rule not proceeded so far, but peculiar and characteristic structures are presented by *Barycrinus*, *Herpetocrinus*, the Platycrinidæ (*sens. str.*), *Crotalocrinus*, *Cupressocrinus*, and a few others. The majority of Palæozoic columnals, however, are simply circular in section with their joint-surfaces marked by radiating striæ; such specimens are the terror of the palæontologist. Nevertheless stem-characters, even in unpromising genera, deserve careful study. In

Herpetocrinus they afford the only means by which species can be distinguished.

It is a remarkable fact that some genera and species which appear closely allied differ in the mode of growth of the stem. "The internodes of some species begin at quite a distance from the calyx, while others have no internodal joints at all." In the Ichthyocrinidæ the proximal region of the stem consists of low ossicles, with no internodals, varying from 20 to 50 but nearly constant in number in the same species. *Platycrinus* has no internodes, but *Marsupiocrinus* has them well defined. *Mespilocrinus* has no internodals. *Rhodocrinus* has "but a single ossicle to each internode." Two Gotland species of *Gissocrinus* (*G. typus* and *G. campanula*) are much alike, and often I was only able to distinguish specimens by the number of the internodals, a feature imperceptible to the unaided eye.

Further study of the mode of growth, of external ornament, of joint surfaces, of the shape of the axial canal, and of the relations of cirri, with the consistent tabulation of these characters, may some day enable us to draw up a key. The difficulties are two: the changes of character in the different regions of the same stem; and the extreme rarity of complete stems in association with crowns. Still the work has to be done, and the amount already accomplished by Messrs. Wachsmuth and Springer suggests that the task is no impossible one. Let the student enter the field to which they have pointed the way.

Further remarks on minor points suggest themselves.

"In a few Palæozoic Crinoids, the whole stem is divided longitudinally, its joints being either quinque- or tri-partite. The former is the case in *Ohiocrinus*, *Ectenocrinus*, *Barycrinus*, *Anomalocrinus*, and probably others; while a tripartite stem has been observed only in *Heterocrinus*" (p. 41). In this sentence the names *Ectenocrinus* and *Heterocrinus* should be interchanged. The words "probably others" understate the case, since a quinquepartite stem has already been described and figured for *Cleiocrinus*,[1] *Thenarocrinus*,[2] *Botryocrinus*,[2] *Mastigocrinus*,[2] *Streptocrinus*,[2] *Ottawacrinus*,[3] *Euspirocrinus*,[2 3] *Vasocrinus dilatatus*, *Calceocrinus pinnulatus*,[2] and *Rhodocrinus asperatus*,[1] while traces of similar sutures have been proved in *Herpetocrinus*.[2] Other examples of quinquepartite stems are known, but have not yet been referred to any genus. In short a large number, if not the majority, of Lower Palæozoic genera had the stem so divided. The character is obviously a primitive one, but its meaning need not again be discussed.[4]

Another sentence, suggesting that this section was written many years ago and has escaped revision, is the statement that "In the Cyathocrinidæ the structure at the lower part of the stem is only known in *Barycrinus*." I should not put *Barycrinus* in the Cyathocrinidæ myself; but if it is to go there, so also must *Botryocrinus*, *Mastigocrinus* (which, indeed, Wachsmuth considered "merely

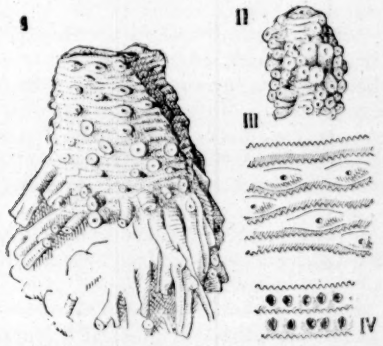
[1] By E. Billings. [2] By F. A. Bather. [3] By W. R. Billings.
[4] See "Royal Natural History," vol. vi, pp. 296–7; Warne & Co., 1896.

a variety of *Cyathocrinus* "), and *Thenarocrinus*, in all of which the root was described and figured more than six years ago. The distal end of the stem is likewise known in *Gissocrinus*, *Euspirocrinus*, and *Bactrocrinus*, which also are placed in the Cyathocrinidæ on the authority of Wachsmuth and Springer in Eastman's adaptation of Von Zittel's "Palæontology."

This section contains numerous interesting observations on the cirri, chiefly of Palæozoic crinoids. These structures were no doubt less specialized in the older crinoids, especially in Camerata; but this is no adequate reason for the suggestion that they should "receive a different appellation." Cirri seem to have originated as branchings of the distal end of the stem, radical cirri; these branches subsequently appeared at higher levels, and became more definite in arrangement; the cirri in older genera were often large and branched; they became eventually small in comparison with the stem, unbranched, attached by more definite facets, and with greater activity of movement. But all these changes can be traced; there is a regular evolution, comparable to the evolution of pinnules; and as to the homology of the diverse forms, there can be no question.

Our authors hint that the cirri of Palæozoic crinoids may have opened out at their ends. "The finest hair-like branches which have come under our observation are perforated at their extremities." They seem to think that the canal of the cirrus may have admitted water to the axial canal of the stem; they point also to the pores occasionally found in the distal region of the stem as serving the same function; but they do not seem to have discovered the intimate connection of these pores with the cirri. A branch of the stem naturally contained branches of the axial blood-vessels and nerves; these became the axial cords of the cirri. After atrophy of the cirri, there still remained the extensions of these soft parts through the wall of the stem, each such extension representing the former attachment of a cirrus. The cavities left by these in the dead stereom are the so-called 'pores'; their evolution may be traced in good specimens of the root of *Crotalocrinus* (Figs. I–IV), but they are not confined to that genus. The greater size of the stem-lumen in so many Palæozoic genera is explicable on the theory of the evolution of the stem as a plated evagination of perisome such as is seen in some Cystidea; there is no need to suppose for it any particular function. Its gradual diminution in phylogeny is precisely paralleled by the evolution of the cephalopod siphuncle, which likewise began as a visceral cone. The idea that streams of sea-water passed in through the cirri, or pores, or grooved channels on the under surface of the root, and bathed the folded inner walls of the axial canal as though these were gills, does not seem consistent with the general scheme of crinoid morphology and physiology. It is about as happy as Miller and Gurley's theory that "the mucous or fluid substance, that contained the material for the base, passed through the columnar canal into the pores of the base and was deposited in a softer state than it afterward assumed." We may, however, suppose that these passages

served the double purpose of transmitting nutrient fluid to the mesoderm cells depositing the outer layers of stereom, as the stem and root grew wider by concentric accretion, and of aerating the same fluid by bringing it near the oxygenated sea-water.



THE DEVELOPMENT OF 'PORES' FROM CIRRI.

I.—*Crotalocrinus*; portion of Root, with branching cirri below, and attachments of cirri in upper part. These latter show the axial canal that passes from the main axial canal of the stem, through the thickness of the columnals, to each cirrus, and continues to the end of the cirrus. Specimen from Silurian of Gotland. British Museum, regd. E 1,273. Nat. size.

II.—*Cystocrinus tennesseensis*; part of stem, showing stumpy aborted cirri, with axial canals opening at their ends. Niagara group, W. Tennessee. Brit. Mus., regd. E 53 (*a*). Nat. size.

III.—*Crotalocrinus*; part of stem, showing crenulate sutures between columnals, and on the columnals the atrophied attachments of cirri; compare with the extreme upper part of Fig. I. Wenlock Limestone, Much Wenlock. Brit. Mus., regd. E 6,633. × 5 diam.

IV.—*Crotalocrinus*; part of stem, showing total disappearance of cirrus-attachment, and only the axial canals remaining as 'pores' piercing the columnals. Silurian, bed *f* of Lindström, near Pafvalds, Gotland. Brit. Mus., regd. E 6,139. × 5 diam.

It is not quite clear what importance Messrs. Wachsmuth and Springer attach to the conception of the dorso-central. It is not necessary to repeat the reasons why "the dorso-central, considered as a morphological element of the Echinoderm type, has got to go."[1] There remains, however, the question whether it can be considered an independent element of the Crinoid skeleton. Since the distal segment of the stem always remains distal, no fresh ossicles ever being developed between it and the sea-floor, it is clear that it is homologous in all crinoids. In *Antedon*, as we have long known, this distal element forms no part of the adult, but is left behind when the animal enters on its free-moving existence. This is also the case in the Pentacrininæ, and Messrs. Wachsmuth and Springer have collected evidence to show that the same phenomenon was

[1] "The text-book writer among the Echinoderms," *op. cit. antea.*

common in various Palæozoic genera. In Actinocrinidæ, Platycrinidæ, and other forms "the terminal part tapers rapidly to a point, and cirri are given off from the sides." This end is "not homologous with the part by which the young Crinoid had been formerly attached, but is a product of later growth." But all this has nothing to do with the character of the original distal end. The term dorso-central was applied to the distal segment of the stem in the larval *Antedon rosacea* (or *A. bifida*) because it was seen to be a flat cribriform plate, whereas the penultimate segment was an elongate columnal formed of fasciculate stereom. The necessity for a distinct term depends on two considerations: (i) the universality of the occurrence of such a plate; (ii) the morphological difference between cribriform and fasciculate stereom. As to (i), Wachsmuth and Springer infer from the development of *Antedon* and from palæontological evidence, "that the young Palæocrinoid in its early life was attached by a dorso-central." But the palæontological evidence adduced is of the slenderest description: "In only two instances do we know that [adult] Palæozoic crinoids were attached by what appears to have been originally a dorso-central plate: in '*Cheirocrinus*' *clarus*[1] and in *Eucalyptocrinus crassus*."[2] The former instance shows an encrusting root with lobate edges; the latter shows a slight terminal swelling from which proceed numerous branching, radical cirri. Our authors consider the lobations of the former as 'budding cirri,' while, with reference to the well-known roots of *Eucalyptocrinus*, they write: "These roots seem to have been derived from a central disk (dorso-central), from which the numerous branches were given off in a similar manner as the immature cirri from the terminal plate of '*Cheirocrinus*' *clarus*." The only other instance of a terminal plate quoted by them is from the Hudson River group of Cincinnati. Here "we occasionally find crinoidal disks, attached to pieces of coral, which closely resemble the dorso-central of *Antedon*. These disks have a pit or depression at the middle of the upper face, sometimes enclosing a small stem joint. They are irregularly round, and some of them have small processes passing outward from the sides, which seem to represent primitive cirri." Clearly these objects are of the same nature as those from the Niagara group of New York, to which Hall gave the name *Aspidocrinus*. It is conceivable that they are, or may be, of the same nature as the terminal plate of *Antedon rosacea*. But these three or four instances are scarcely evidence that all or even the majority of Palæozoic crinoids were at one time of their lives attached by a dorso-central. An encrusting root is not necessarily the homologue of a single cribriform plate, as study of the root of *Apiocrinus* will speedily reveal to anyone. Besides, admitting the secondary nature of many branching or tapering roots, we have no evidence that they were preceded by dorso-centrals. But, turning to (ii), we ask whether there really is any difference

"[1] N.Y. State Cab. Nat. Hist.; Fifteenth Rep., Pl. i. Figs. 17 and 18."
"[2] N.Y. State Mus. Nat. Hist.; Twenty-eighth Rep., Pl. xvii, Fig. 5."

between the distal element named dorso-central and the other elements of the stem. W. B. Carpenter's refusal to recognize a morphological distinction between cribriform and fasciculate stereom has already been quoted. That there is no physiological distinction between these elements, in *Antedon* itself, is seen by reference to the figures of *A. Sarsi* published by M. Sars.[1] These show that any columnal could form encrusting or lobate extensions over adjacent objects. Except as a misleading and highly confusing appellation for the primitive distal columnal, there is therefore no virtue in the term 'dorso-central.'

This conclusion does not affect the main thesis of Wachsmuth and Springer, that the majority of Palæozoic crinoids were not permanently attached. "A permanent fixation of the Crinoids would perhaps restrict the geographical range of the species, whereas we know that some of them have a very wide range. A majority of the species from the Lower Burlington group at Burlington are found almost unaltered in the south-western part of New Mexico, and some in Arizona, and many species of the Keokuk group have been traced from Southern Iowa as far down as Alabama. And we find in Scotland and Eastern Russia, with but slight modifications, the same forms which flourished in the Mississippi Valley during the epoch of the Kaskaskia group" (p. 52).

The important question of the orientation of the stem is best dealt with in connection with the structure of the base of the cup, which will be discussed in the next Notice. F. A. Bather.

(*To be continued.*)

II. — The Geology of the Country around Bognor. By Clement Reid, F.L.S., F.G.S. Memoirs of the Geological Survey. 8vo; pp. iv, 12, with 14 illustrations. (London, 1897. Price 6*d*.)

THIS little memoir has been prepared to illustrate the New Series Map Sheet 332, embracing that part of the Sussex coastline which projects in Selsey Bill and includes the favourite seaside resorts of Bognor and Littlehampton. The most interesting features in the geology are in connection with the Bracklesham Beds, which being exposed only on the foreshore must be studied at low-water spring-tides; then "one sees laid bare some of the finest exposures of fossiliferous strata visible in England." Several of the characteristic fossils are figured in this memoir, which should prove a useful guide to the student. The Pleistocene deposits with their far-travelled erratics also possess many points of interest on which Godwin-Austen very many years ago, and the author more recently, have thrown much light.

[1] "Mémoires . . . . des Crinoïdes vivants": Progr. Univ. Norvège; Christiania, 1868. See pl. v, figs. 9, 12, 13, 15.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 18, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Garnet-actinolite Schists on the Southern Side of the St. Gothard Pass." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author describes the field relations and the microscopic structures of a group of schists or gneisses characterized by the frequent presence of conspicuous garnets and actinolites, which are exposed on the southern slopes of the St. Gothard Pass and for some distance west and east, on the northern side of the Val Bedretto. These, called for purposes of reference the Tremola Schists, he has examined from time to time since 1878, the last occasion being the summer of 1897, when he was accompanied and aided by Mr. J. Parkinson, F.G.S. These rocks in the field might be regarded as highly altered sedimentary strata (as the author once thought) or as a group of igneous rocks (originating possibly in magmatic differentiation) affected by fluxion-movements anterior to consolidation. To the latter view he now inclines, but considers the schistosity and the peculiar minor structures to be the results of crushing (generally without marked shearing) followed by very considerable mineral reconstruction. The garnets he holds to be anterior to this crushing, but the larger biotites and the conspicuous actinolites to be posterior to it. These minerals, in his opinion, throw some light on processes of crystallization in rocks more or less pulverized, or, in other words, in the presence of various impediments. He thinks it probable that the Tremola Schists assumed their present form prior to the great Tertiary earth-movements which gave rise to the existing Alpine chain.

2. "On the Metamorphism of a Series of Grits and Shales in Northern Anglesey." By Charles Callaway, M.A., D.Sc., F.G.S.

These rocks occur in a patch about three miles square, situated south-west of Amlwch, and extending from Llanfechell and Rhosbeirio to the boundary fault near Melin Pant-y-gwydd, and from Mynydd Mechell to Bodewryd. They dip to the north, and apparently form a series in the following ascending order:—(1) Highly quartzose and gritty rocks. (2) A considerable admixture of softer beds (hypometamorphic shales). (3) Predominating shaly strata with gritty seams in subordinate proportion. The lower beds contain intercalated seams of well-foliated micaceous or chloritic schist, and in these lower beds the signs of compression and contortion are most marked.

A series of microscopic slides from Rhosbeirio, Llanfechell, Pant-y-glo, and intermediate localities links together the fragmental rocks with the true schists. Grains of clastic quartz are replaced by "granular particles fitting into each other with foliate interlocking

margins"; when in contact "the grains are moulded into each other, and welded together"; but when "entirely immersed in a soft matrix of mica or chlorite," they "still retain their sharp outlines." In the "matrix" the chlorite and mica flakes are gradually enlarged.

While "mechanical force has been concerned in producing the more intense metamorphism of the lower part of the series," the author is "not disposed to advance this as the sole cause of the changes produced."

3. "On a Volcanic Series in the Malvern Hills, near the Herefordshire Beacon." By Henry Dyke Acland, F.G.S.

These are the rocks described briefly by Dr. Callaway and Mr. Rutley, and afterwards more fully by the late Professor A. H. Green. They consist of tuffs, rhyolites, andesites, and dolerites or basalts. The microscopic appearance of the rocks exposed in excavations for a new reservoir between Tinker's Hill and Broad Down indicates that they are much crushed; indeed, the amount of infiltrated calcite often causes the rhyolites to assume the aspect of limestones. On Tinker's Hill there is less crushing. On Hangman's Hill there are rocks allied to epidosites.

It is suggested that the rocks may be the volcanic equivalents of the plutonic rocks of the Malvern axis faulted down and protected by the bend in the axis which occurs in the neighbourhood of the Herefordshire Beacon.

II.—June 8, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Discovery of Natural Gas in East Sussex." By C. Dawson, F.G.S., F.S.A.

Inflammable natural gas was first recorded by Mr. H. Willett in his thirteenth quarterly report of the Subwealden Exploration. Another discovery was in a deep artesian boring in the stable-yard of the New Heathfield Hotel. In 1896, at a site about 100 yards distant from the last-mentioned locality, a boring was put down by the London, Brighton, and South Coast Railway Co., the details of which are given in the paper together with those of the earlier Heathfield boring. From this boring gas has been escaping for the last 18 months, with a pressure of not less than 15 lb. to the square inch, and at the rate of about 12¼ cubic feet per hour (with a pressure of 20 tenths maintained), although the tube is stopped up, and is partially filled with water.

Though deficient in illuminating quality, the gas burns well when mixed with air and gives a good bunsen-flame. The author considers that it is probably derived from the lower beds pierced, that is, the Purbeck strata, or by percolation from the still lower Kimeridge beds, which were not reached by the borings. The borings pierce the southern slope of the great anticline which runs from Fairlight into Mid-Sussex, and is joined at Heathfield by another considerable anticline running through Burwash.

2. "Note on Natural Gas at Heathfield Station (Sussex)." By J. T. Hewitt, M.A., D.Sc., Ph.D. (Communicated by the President.)

A sample of natural gas from a boring at Heathfield was taken in December, 1897, analyzed with the following result:—

Methane	91·9
Hydrogen	7·2
Nitrogen	0·9

Oxygen, carbon dioxide, carbon monoxide, olefines, and hydrocarbon vapours were altogether absent.

A specimen of a bed of lignite (dried at 110° Centigr.) was also analyzed:—

	Total analysis.	Percentage of organic materials.
Carbon	9·43	51·87
Hydrogen	1·83	10·07
Nitrogen	0·68	3·74
Sulphur	1·27	6·99
Oxygen	4·97	27·33
Ash	81·82	...
	100·00	100·00

An analysis of the ash is also given in the paper.

3. "On some High-level Gravels in Berkshire and Oxfordshire." By O. A. Shrubsole, F.G.S.

The high-level gravels are divided by the author as follows, beginning with the oldest:—

1. Pebble-gravel, composed very largely of flint or chert.
2. The Goring Gap gravel.
3. Quartzose gravel, with only a small proportion of flint-pebbles.
4. Quartzite-gravel, with purple and brown quartzite-pebbles.
5. Local flint-gravels.

The pebbly contents of these gravels are expressed in percentages. The Pebble-gravel occurs on the higher plateaux of the Chiltern Hills, and a suggestion is thrown out that it may possibly be of Diestien age. The Goring Gap gravels contain a large proportion of subangular flint. The Quartzose gravels are distinguished by a certain proportion of opaque and vitreous quartz-pebbles and a small number of quartzite-pebbles, generally pale in colour: a small flint-flake was found in them at Bowsey Hill; amongst the possible sources of the constituents of this bed, old pebble-beds like those of Potton and Upware are mentioned. The Quartzite-gravel is widespread, and is found at heights varying from 294 to 544 feet. There is a gravel-pit near Moreton-in-the-Marsh, close to the source of the Evenlode, which shows an exceptionally large proportion of quartzite-pebbles, both smaller and larger than 6 inches in diameter. Farther on, similar gravels may be traced through Evesham, up the Salwarp valley, and into the Lickey district; the author conjectures that the source of the quartzite-pebbles may lie in the direction of Warwickshire and the Midlands. Small flint-flakes usually having one bulb

of percussion have been found in all the gravels except the oldest. The value of these flakes as evidence is disputed.

4. "The *Globigerina*-marls of Barbados." By G. F. Franks, F.G.S., and Prof. J. B. Harrison, M.A., F.G.S. With an Appendix on the Foraminifera by F. Chapman, F.R.M.S., A.L.S.

After a reference to previous publications on the island by one of the authors and Mr. Jukes-Browne, an account is given of the tectonic structure of Bissex Hill, on which the principal exposures of the *Globigerina*-marl occur. Five faults are described, four of which cut all the rocks, while the fifth disturbs the Scotland Beds and the Oceanic Series, but leaves the overlying *Globigerina*-marl undisturbed.

The general succession is as follows:—The Scotland Beds are overlain unconformably by the Oceanic Series, which shows the usual succession from chalks to calcareo-siliceous beds, and in places to the upper chalks, the overlying red clays being absent. Then follows unconformably a detrital bed of *Globigerina*-marl containing rolled pebbles of various parts of the Oceanic Series, especially the chalks, and inclusions of clay presumably from the Scotland Beds. The bed is followed by buff marls, granular in appearance, and this, again, by marls and limestone, in the upper part of which *Globigerinæ* die out and are replaced by *Amphistegina* and fragments of lamellibranch shells. The whole succession is about 90 feet in thickness, and the beds pass up into basement-reef rocks without coral, and coral-rock.

Somewhat similar rocks were met with in a shaft at Bowmanston, and they probably occur in other localities. The presence, succession, and relations of these rocks enable the authors to draw conclusions as to the history of the island.

In the Appendix a list of 146 species of foraminifera is given: 15 of these occur only in strata ranging from the Cretaceous to the Pliocene Period. The rocks bear some resemblance to the limestones and marls of Malta and to the *Globigerina*-beds of Trinidad; the recent foraminifera indicate that the deposit was formed at a depth of about 1,000 fathoms and at some distance from land.

CORRESPONDENCE.

EBBING AND FLOWING WELLS.

Sir,—At the meeting of the Geological Society of London, on April 20th, 1898, were read notes on the ebbing and flowing well at Newton Nottage, Glamorganshire, by Mr. Madan, M.A., communicated by Mr. A. Strahan, M.A.

The well lies about 500 yards from the sea, with sandhills between, and in the neighbourhood of a range of Carboniferous Limestone, whilst the same formation crops out in the sea at half-tide level. At the shore junction of conglomerate and limestone numerous springs occur, and it is in this conglomerate that the well is sunk. After many observations, the author has constructed

a curve showing the relationship existing between the rise and fall of the tide and that of the water in the well. From the position of the well in question and its surroundings, possibly the ebbing and flowing of the tide may produce the ebb and flow of water in the well, but there are other ebbing and flowing wells so situate that tidal variation can have on them no influence. Some few years back I was staying at Buxton, and frequently walked to Castleton. By the side of the road I noticed an ebbing and flowing well, but the variations of condition did not assert themselves at stated or defined times; on the contrary, the changes were erratic. One thing is certain, tides could here have no effect, since, as the crow flies, the distance from the estuary of the Mersey, the nearest point to the sea, is upwards of forty miles. How, then, can these variable conditions be explained? On the spot I could collect no information. The theory I propounded was this. The district is Lower Carboniferous Limestone, and, taking into account the results of the chemical action of underground water, the internal composition of the rocks become altered, large quantities are carried away, with the result that subterranean tunnels and cavities are formed, and if in the upper parts of this mountain limestone a spring or springs exist, the overflow would find its way by tunnels into the eroded cavities, from which it might be syphoned to the well below, producing the changes which perplex the traveller.

Caverns are abundant in the Carboniferous limestones. There is the peak cavern at Castleton. The Victoria Cavern, at Settle, Yorkshire, contains forms which favour my theory, since it has deep shafts and caverns inclining inwards. There is also recorded a fissure communicating with a basin in the limestone at Windy Knoll, near Castleton.

T. E. Knightley.

106, Cannon Street, E.C.
May 19th, 1898.

SACCAMMINA CARTERI AND *NODOSARIA FUSULINIFORMIS*.

Sir,—In consequence of the paper by Mr. F. Chapman, in the Annals and Magazine of Natural History for March, 1898, in which he so properly connects *Saccammina Carteri* with *Nodosaria fusuliniformis* of M'Coy, I have sought for the second type-specimen referred to by M'Coy. It has now been placed in the wall-case containing fossil Foraminifera in the Museum of Science and Art, Dublin. It fully justifies Mr. Chapman's published conclusions, which were based upon the Cambridge specimen. There seems no doubt that we must now accept *Saccammina fusuliniformis* as the name of this well-known species.

Grenville A. J. Cole.

Science and Art Museum, Kildare Street, Dublin.
May 21st, 1898.

BOULDERS OF SPILSBY SANDSTONE.

Sir,—In his interesting note on a boulder of Spilsby Sandstone, at Wimpole, in Cambridgeshire (Geol. Mag., June, 1898, p. 267), Mr. Cowper Reed rightly observes that no block so large, and bearing such a definite proof of its origin, has previously been

discovered in the area. I may, however, recall attention to the Merton Boulder, which lies on the estate of Lord Walsingham, at Merton, in Norfolk. This boulder is regarded by Mr. Whitaker as Neocomian Sandstone, and it measures 12 × 5 feet, but being partly under water its thickness could not be ascertained. (See F. J. Bennett, "Geology of Attleborough, Watton, and Wymondham," Geol. Survey Memoir, p. 10.) A more particular account of the Spilsby Sandstone has been given by Mr. A. Strahan, who refers to its tendency to weather into a loose sand in which great blocks of the unweathered rock remain here and there. Hence during the Glacial Period a number of ready-made boulders could have been obtained from the formation. Such blocks have, indeed, been recorded from the Drift in various parts of Suffolk, and some of them have yielded Brachiopoda regarded as Neocomian by W. Keeping and Davidson. (See Strahan, in "Geology of the Country around Lincoln," p. 88.)

H. B. Woodward.

THE LLANBERIS UNCONFORMITY.

Sir,—The courteous letter, which you publish from Professor Bonney in your June number, calls for only two remarks. (1) I am not aware that Professor Bonney has in any case tried to find out *for himself* whether any stratigraphical statement of mine is fact or fancy. (2) To have once silenced a gun is not to take the fort. How many of the ship's guns are still in action?

J. F. Blake.

OBITUARY.

MELVILLE ATTWOOD, F.G.S.

Born July 31, 1812. Died April 23, 1898.

Melville Attwood was born at Prescott Hall, Old Swinford, Worcestershire, on July 31, 1812, and educated at Mathew Gibson's Academy, Tranmere, Cheshire, and afterwards studied at the Chemical Laboratory of Messrs. Watson and Pim, of Liverpool.

When quite a young man he was sent out to the Gold and Diamond Mines in Brazil, where he remained some years; on his return to England he leased and worked the celebrated Old Ecton Copper Mine in Derbyshire, and was engaged in mining and metallurgical works in the North of England and Staffordshire, and in 1843 he gave zinc a commercial value by successfully rolling the first English spelter. On the 15th October, 1839, he married Jane Alice Forbes, the sister of the late Professor Edward Forbes and of David Forbes, F.R.S., but in 1852, his wife's health becoming critical, he disposed of his interests and sailed for California, hoping that the change might benefit her; at the same time he accepted the position of manager to the Agua Fria Gold Quartz Company (in California), and in 1853 constructed at Grass Valley the first gold-mill in that country, for which he received a vote of thanks and a medal from the State of California.

He invented many appliances for the extraction of gold, also scientific instruments, and the "Attwood amalgamator" has been in general use in California and elsewhere for more than forty years.

In 1859 he made the first assays and analyses of the ores from the celebrated Comstock Gold and Silver Vein; and it was through him that the great riches of the above vein were made known to the world.

For the last twenty-five years nearly all his spare moments were given to microscopic work; he prepared his own specimens, and he leaves behind him a most valuable collection of minerals and microscopic slides. He was an intimate and esteemed friend of the late Sir Warington Smyth, Dr. John Percy, John Arthur Phillips, F.R.S., and other well-known scientific men.

He was able to practise his profession of consulting mining engineer until within a few weeks of his death, which took place at Berkeley, near San Francisco, California, on April 23, 1898, in his eighty-sixth year. His practical experience in gold-mining extended for a period of seventy years, as he was in the Brazilian gold-mines before he reached the age of seventeen.

He was a Fellow of the Geological Society, a Member of the Academy of Sciences (California), California State Geological Society, and the San Francisco Microscopical Society. The members of the last-mentioned Society attended in a body the funeral on April 26, with numerous old-time friends.

His contributions to the California Mining Bureau and scientific papers and magazines were numerous. The following is a list of some of his principal writings:—

"On the Milling of Auriferous Vein Stones," August 1, 1878: California State Geological Society.

"Mineralization of Gold," August 20, 1878: California State Geological Society.

"On an Improved Form of Batéa," August 20, 1878: California State Geological Society.

"Wall Rocks of the Bodie Auriferous Lodes," March 4, 1879: California State Geological Society.

"Rough Notes on the Geology of Bodie, illustrating the two ages of Gold," June 13, 1881: San Francisco Microscopical Society.

"On the Milling of Gold Quartz," August 20, 1881: California State Geological Society.

"On the Milling of Gold Quartz," sequel to above paper, 1882: California State Mining Bureau.

"A simple Working Test for determining the quantity of Gold mechanically combined with Auriferous Vein Matter": California State Mining Bureau.

"Gongo Soco Mine," 1896: San Francisco Microscopical Society.

"Macroscopical Examination," February 14, 1897: San Francisco Call.

"Mineralogy," 1897: San Francisco Microscopical Society.

GEORGE ATTWOOD.